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Abstracts Bulletin

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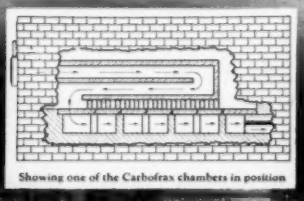
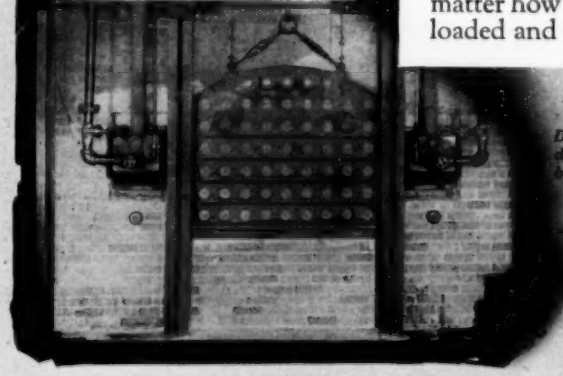


Showing one of the Carbofrax chambers in position



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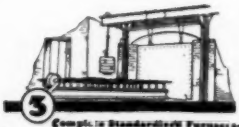

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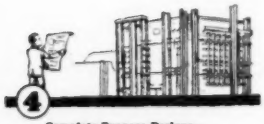

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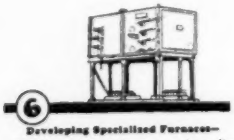

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ORIGINAL PAPERS

THE PLASTIC PROPERTIES OF ENAMEL SLIP

By R. D. Cooke

ABSTRACT

A simplification of the Bingham Plastometer, applicable to enamel slips, is described and the theory of plasticity discussed briefly.

It was found that increase in temperature or increase in water content of enamel slips raised the mobility without greatly affecting the yield value. Addition of clay and of certain inorganic salts raised the yield value without changing the mobility. Sodium silicate reduced the yield value to zero and lowered the mobility.

There have been numerous attempts to evaluate the consistency of enamel slips by various methods, most of which depended on some form of viscosity measurement. Bingham[1] has recently pointed out that all attempts to measure the viscosity of suspensions of solids in liquids have been based on the erroneous assumption that these suspensions behaved like true liquids. He has shown that under different conditions of pressure and size of capillary different apparent viscosities will be found because these plastic materials are in reality soft solids, and that solids require that the elastic limit or *yield value* must be exceeded before they will begin to flow.

With this concept in mind it will be apparent that, considering the flow of a plastic solid through a capillary, if a number of different stresses (pressures) are employed a number of different rates of flow will be found which when plotted against the corresponding stresses will lie on a straight

[1] "Fluidity and Plasticity," McGraw-Hill, 1922.

line. This line when extrapolated to zero rate of flow will not intersect the pressure axis at zero as would be the case with a true liquid. The intersection will be at some definite pressure, which is proportional to the yield value. This represents the minimum pressure required to start the flow with that particular capillary. The slope of the line represents the *mobility*, analogous to fluidity of a liquid, and gives a second property of plastic substances.

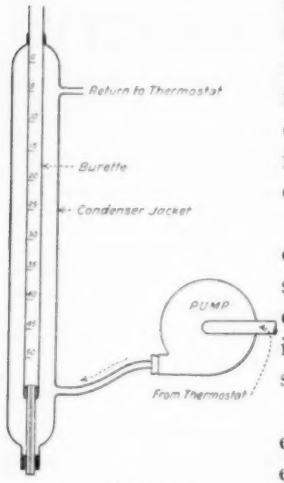

FIG. 1.

These two properties, yield value and mobility, completely define the characteristics and consistency of a suspension. They are independent of each other and cannot therefore be combined into a single expression as has been assumed in so-called viscosity measurements.

In practice, to make measurements on different instruments comparable, it is convenient to express the stress in dynes per square centimeter, taking into consideration the dimensions of the capillary. The theoretical details are discussed fully by Bingham.[1]

It became apparent that enamel slips fall into the class of plastic solids according to these conceptions. In practical terms the yield value is that property of enamel which causes it to hold its form up to a certain thickness when applied to ware in spite of definite forces (gravity, inertia and centrifugal force) tending to make it flow. It is the property commonly spoken of as shortness. The mobility has a less important practical bearing, but it is the property which makes an enamel flow more or less readily under forces greater than the yield value. The desirable condition of an enamel is a yield value commensurate with the thickness of coating desired, and a high mobility. A knowledge of the yield value and mobility of enamel slips explains their working properties in a perfectly logical way.

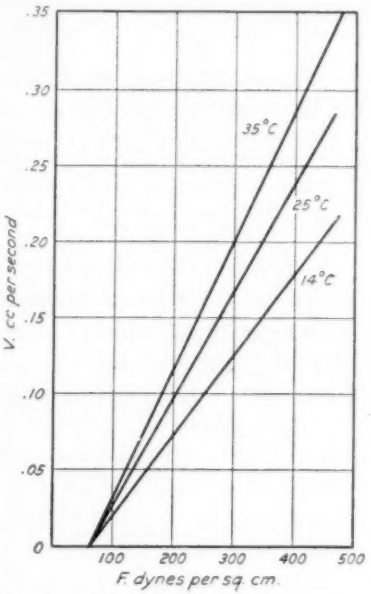

FIG. 2.—Effect of varying temperature.

A few determinations of these two properties have been made on typical

[1] "Fluidity and Plasticity," McGraw-Hill, 1922.

enamels under different conditions, and while not complete nor of particular interest in themselves the method used may be of interest to those desiring to follow out these concepts of plasticity. The apparatus in the form used by Bingham was found unsuitable because the very small capillary tubes were arched over and stopped up by the larger particles of enamel frit. When larger tubes were used it was found that the pressures required were so low that they could not be controlled accurately.

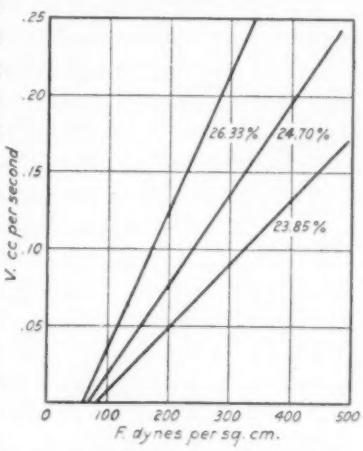

FIG. 3.—Effect of varying water content.

A modification was adopted which, while less exact, made use of the identical principles, gave good results and was several times more rapid. Referring to Fig. 1, the enamel slip was placed in a burette having the stop-cock replaced by a rather large capillary tube. The burette was enclosed in a water jacket through which water from a thermostat was pumped to maintain constant temperature. The enamel was previously brought to the same temperature by letting it stand in the thermostat in a flask. As the enamel flowed from the burette through the capillary the pressure due to the hydrostatic head was decreasing and the rate of flow was also decreasing. By taking the average pressure and the average rate for each five cubic centimeters outflow, data were available for plotting a curve from which the yield value and mobility could be read. The times at which the top surface of the enamel passed zero, five cubic centimeters and each multiple thereof were taken with a split hand interval timer. The corresponding average height or hydrostatic head for each interval was the distance from the lower end of the capillary to the 2.5, 7.5 cc. marks, etc.

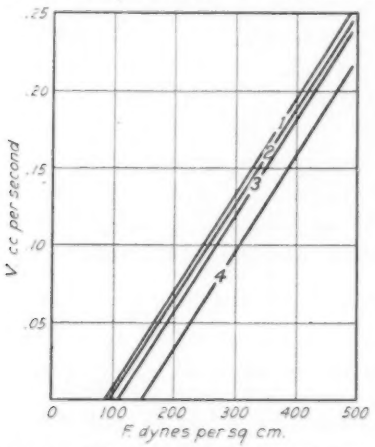

FIG. 4.—Effect of varying clay content.

1—4%	3—6%
2—5%	4—7%

Following are the data for the instrument and the record of a typical run.

F—the shearing stress in dynes per square centimeter $= \dfrac{RhDg}{2 \times l}$

where R = radius of capillary—.09247 cm.
h = height of enamel in tube in cm.
D = density of enamel.
g = 981, gravitational constant.
l = length of capillary—9.27 cm.

Cc.	*t*	*Dt*	*r*	*h*	*F*
0	0	.....	.....	....	...
5	23.4	23.4	0.214	54.6	491
10	47.9	24.5	0.204	49.9	449
15	75.6	27.7	0.181	45.3	407
20	107	31.4	0.159	40.6	365
25	143	36	0.139	36.0	324
30	186	43	0.116	31.4	282
35	238	52	0.096	26.8	241
40	308	70	0.071	22.1	199
45	415	107	0.047	17.4	156
50	615	200	0.025	12.7	114

Density of slip = 1.838.

All of these quantities were constant except the density and the series of h's, which were the same for every run. In a typical run the following values were tabulated. $Cc.$ = burette reading; t = time in seconds; Dt = time interval in seconds; r = rate of flow in cc. per second = $5/Dt$; h = height of column in cm.; F = shearing stress in dynes per square cm. The values for r and F were plotted against each other on cross section paper, and the result was an approximately straight line intersecting the F axis at the yield value, f. The slope of the line, $\frac{r}{F-f}$ multiplied by a constant equal to $\frac{4}{\pi R^4}$ equals the mobility. The above example is shown plotted in the 14° curve on Fig. 2. The yield value was 64 dynes per square cm. and the mobility .8551. It is possible to determine the yield value algebraically from the data, but the graphic method is much to be preferred.

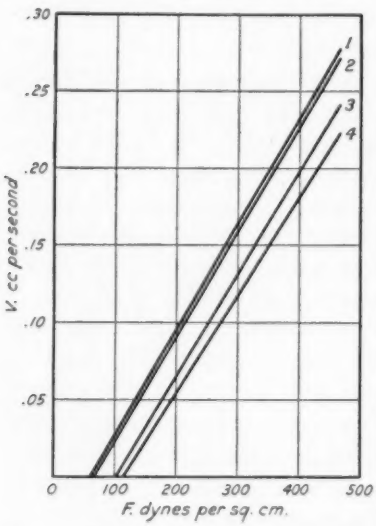

FIG. 5.—Effect of adding magnesium sulphate.

1—none 3—.050%
2—.025% 4—.075%

The accompanying charts show the effects of varying certain conditions on the characteristic curves for enamel slips.

Figure 2 shows that raising the temperature from 14°C to 35°C, increased the mobility 60% without changing the yield value.

Figure 3 shows that increasing the water content from 23.85% to 26.33% increased the mobility 120% and reduced the yield value 26%.

Figure 4 shows the effect of increasing the clay content. The yield value was increased without changing the mobility.

Figure 5 shows that addition of magnesium sulphate raised the yield value without changing the mobility materially.

The effects of a number of inorganic salts in chemically equivalent quantities were investigated. It was found that sodium chloride, sodium carbonate, sodium acetate, sodium thiosulphate, ammonium chloride and ammonium carbonate increased the yield value slightly without changing the mobility. Borax, acetic acid, aluminum chloride and cobalt nitrate increased the yield value considerably without changing the mobility. Magnesium sulphate, barium chloride and calcium chloride increased the yield value enormously and also reduced the mobility. Sodium silicate reduced the yield value to zero and decreased the mobility.

This method for determining the plastic properties of enamels suggests the interesting possibility of studying different clays in this light and determining what properties are desirable for a suitable enameling clay. Bingham[1] has shown that when a given suspension is studied in a wide range of concentrations two other properties appear—the concentration of zero yield value and the concentration of zero mobility. The former is thought to be related to the adsorptive power of the solid for the liquid or the proportion of adsorbed liquid to free liquid. The latter is probably related to the pore space and the distribution of particle size. A study of these properties would unquestionably add much to our understanding of the physical characteristics of ball clays.

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[1] *Jour. Ind. Eng. Chem.*, **14**, 1014 (1922).

THE OXIDATION OF CERAMIC WARES DURING FIRING.—V. A QUANTITATIVE STUDY OF THE NATURE OF SULPHUR EVOLUTION IN KILN FIRING.[1] (PART 2)

By Frederick G. Jackson[2]

Test on a Refractory Kiln

In the previous tests the analyses of CO_2, coal, and ash were from too small samples. The kiln temperature was measured at only one point. The ratio of SO_2 to SO_3 was not determined; and the test was stopped at 1680°F crown temperature.

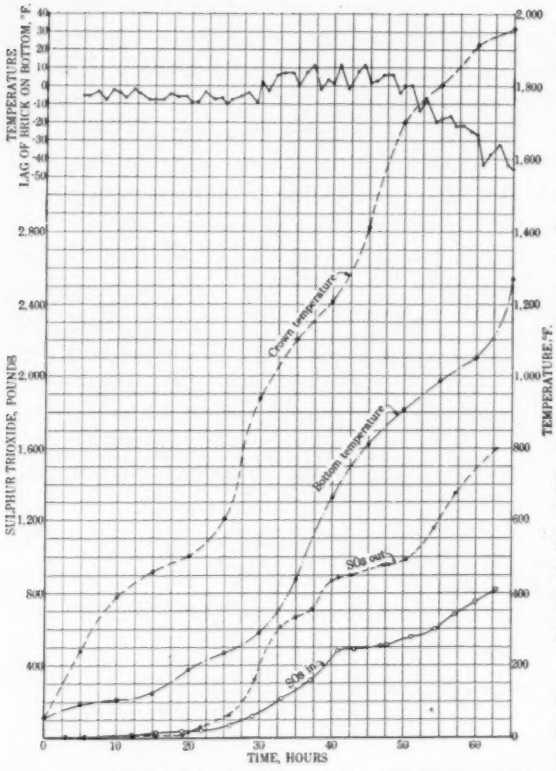

FIG. 7.—Cumulative weights of SO_3 and temperature in kiln.

The U. S. Bureau of Mines in coöperative work with the Refractories Manufacturers Association was studying the burning practice at a plant using a fire clay which contained sulphur and considerable iron. Part of the routine of the crew consisted of making (1) accurate temperature measurements of many parts of the kiln; (2) taking repeated samples of coal and ash and (3) drawing a continuous sample of flue gas which was averaged and analyzed each half hour throughout the firing.

The kiln was round down-draft, 26 feet in diameter with single outside stack. It was set with 40,950 nine-inch equivalents, having a fired weight of 273,500 pounds. The kiln was fired to 2150°F in 80 hours. Ten whole brick draw trials were set on the floor of the kiln, and ten more were arranged at a height of 4 feet from the floor. One from each set was drawn every 8 hours of the burn.

[1] Published by permission of the Director, U. S. Bureau of Mines. For Part I of this paper see *Jour. Amer. Ceram. Soc.*, **7** [8], 634 (1924).

[2] Associate chemist, Ceramic Station, Columbus, Ohio.

Determination of Temperature Lag

A green brick was drilled from the end to the center for insertion of a thermocouple. This brick was set on the kiln floor near the middle. Another thermocouple exposed to the kiln gases was put beside it. The difference in temperature readings of the two couples gave the temperature lag of the brick.

Only the significant data are presented. These are shown in Figs. 7 and 8.

Figure 7 shows (1) the cumulative weight of SO_3 entering the kiln; (2) the cumulative weight of SO_3 leaving the kiln; (3) the temperature of the bottom of the kiln; (4) the crown temperature; and (5) the lag curve of the brick on the bottom of the kiln. Figure 8 shows the cumulative weight of SO_2 entering and leaving the kiln.

Absorption of Sulphur by Ware

The small amount of absorption of sulphur by the ware during "water-smoking" will be noticed at once. This is due principally to the bone-dry condition of the ware, to the grade of coal used, and to the rapidity with which "water-smoking" was accomplished. The coal contained only 0.90% of volatile sulphur. There was consequently very little sulphur entering the kiln during the 22 hours of light firing. The 250 to 450% excess air during this period indicated a good draft which swept out the sulphur gases.

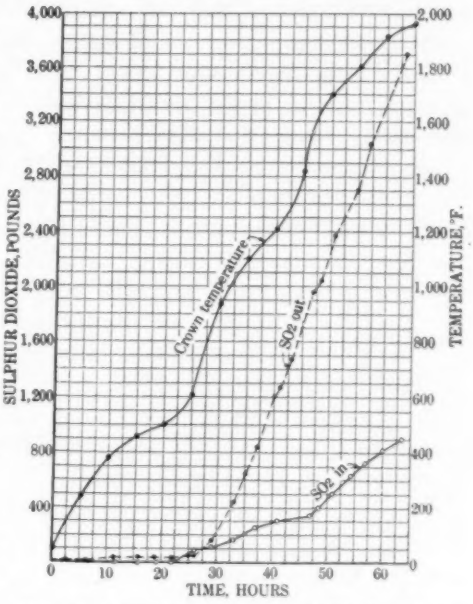

FIG. 8.—Cumulative weight of SO_2 in kiln.

Crown Samples of Gas

Between the 28th and 42nd hours 790 pounds of sulphur seemed to have entered the kiln. Only 351 pounds of this were from the coal. At the 28th hour the excess air was 80%. This made a comparatively still atmosphere in the crown of the kiln, while at the same time the pyrite was decomposing vigorously. The SO_3 and SO_2 thus evolved evidently enriched the sulphur content of the crown gas samples.

Proportions of Gases Evolved

An interesting study of the effect of the amount of excess air is seen in the evolution of gas between the 26th and 33rd hours—498 pounds of SO_3, and only 393 pounds of SO_2 were evolved. There had been a large excess of air up

to the 26th hour, and its effect must have persisted for a little while, so that in the first part of the firing of the pyrite SO_3 formed more than half of the product. Beyond this period oxygen was rare in the kiln. The tendency was therefore to form the compound requiring less oxygen. Between the 33rd and 51st hours 350 pounds of SO_3 and 926 pounds of SO_2 were formed. The ratio of SO_3 to SO_2 is changed from 1:0.79 to 1:2.64. Between the 51st and 63rd hours more SO_3 comes off—630 pounds of SO_3 and 1317 pounds of SO_2. The ratio here is 1:2.09. This increase in the ratio of SO_3 evolved may be due to the catalytic effect of the hotter ware in the lower part of the kiln. It may also be due to the source of the gas, the decomposition of sulphate rather than pyrite. The high ratio of SO_3 during the first of these stages is not explainable on the basis of results found in the second paper of this series; it can best be explained by a selective absorption of SO_2 in preference to SO_3 by the Fe_2O_3 contained in the cooler parts of the ware. When any such absorption takes place, an oxidized iron sulphur compound is formed. It has already been shown that under similar conditions, oxidized compounds decompose at higher temperatures than pyrite, and with the evolution of a higher ratio of SO_3 to SO_2.[1]

Lag Curve The temperature difference between the inside and the outside of a brick at the bottom of the kiln is interesting.

At 30 hours the inside of the brick is for the first time hotter than the kiln atmosphere. At this stage, SO_3 is passing out of the kiln in considerable volume. As this gas penetrates the ware, some of it is absorbed as sulphuric acid and ferric sulphate. The heat generated by these reactions is considerable, and would account for the negative lag. Sulphur dioxide, similarly oxidizing and reacting will have the same effect, and may account in part for the negative lag up to the 42nd hour.

A temperature of 770°F at the 43rd hour probably started the pyrite in the brick to burning. The heat of combustion of the sulphur continued to hold up the temperature inside the brick above that outside until the 51st hour. The decomposition of ferric sulphate is slow, and does not generate appreciable heat, consequently the inside temperature lagged at the last.

Sulphur Balance Since this test was not carried out to the end of sulphur evolution, an actual balance of sulphur cannot be made. The amount of sulphur in all forms at each hour of the

[1] In the second paper of this series it is shown that ferric sulphate in 100% excess air evolved only 15% of its sulphur when heated to 1040°F and then decomposed rapidly. At 1427°F it had evolved 44% of its sulphur as SO_3 and 29% as SO_2. Coarse pyrite under the same conditions evolved 1.30% of its sulphur as SO_3 and 63% as SO_2 between 797 and 833°F.

test can, however, be found. This is interesting for comparison with a similar curve in the previous test.

Sulphur entering the kiln was calculated from the amount of coal fired and the percentage of sulphur therein. Sulphur leaving the kiln was calculated from the weights of SO_3 and SO_2 found by analysis of blue gases. Total sulphur in the ware was estimated at 1.1% from results shown in the next section. There were 3009 pounds of sulphur in the green ware.

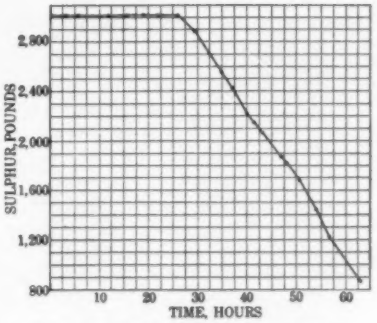

FIG. 9.—Sulphur content of kiln.

The results as shown in Fig. 9 are very different from those on the previous kiln. (Compare Fig. 6.) In that test the ware contained little sulphur, the coal was high in it, and the heating schedule was slow. All three of these factors were reversed in the present test. Added to these is the difference in the character of the two clays. Consequently, the amount of sulphur absorbed was much less. Whereas in the first test 338 pounds, or 27.4%, of the sulphur already in the ware was absorbed, in this test the greatest amount absorbed was 10.8 pounds in 19 hours, or 0.35%. The evolution of sulphur was maintained at an almost constant rate from the time it began, at the 26th hour, until the end of the test. This rate would indicate that all sulphur was out of the kiln by the 76th hour. The kiln was fired for 80 hours.

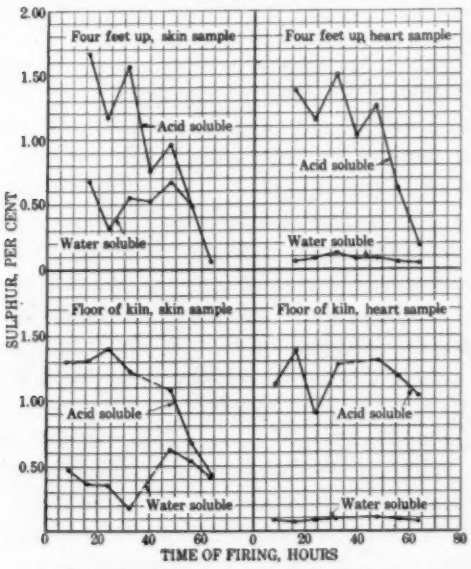

FIG. 10.—Per cent of sulphur in ware.

Draw Trials

Two brick draw trials were taken from the kiln every 8 hours. One row had been set 4 feet above the floor in the kiln, the other row on the floor. These bricks were analyzed as in the previous work, a skin sample and a heart sample from each. Water-soluble and dilute aqua regia-soluble sulphur were determined.

TABLE II—DRAW TRIALS FROM 4 FEET UP IN KILN

Time fired, hours	Skin samples Water-soluble sulphur	Skin samples Acid-soluble sulphur	Skin samples Per cent total sulphur	Heart samples Water-soluble sulphur	Heart samples Acid-soluble sulphur	Heart samples Per cent total sulphur
8		No sample			No sample	
16	0.681	0.978	1.659	0.078	1.306	1.384
24	0.308	0.876	1.184	0.098	1.047	1.145
32	0.539	1.020	1.559	0.125	1.479	1.599
40	0.524	0.223	0.747	0.086	0.949	1.035
48	0.674	0.301	0.975	0.080	1.207	1.287
56	0.393	0.006	0.399	0.058	0.580	0.638
64	0.057	0.001	0.058	0.042	0.153	0.195
		DRAW TRIALS FROM FLOOR OF KILN				
8	0.487	0.813	1.300	0.092	1.035	1.127
16	0.352	0.964	1.316	0.067	1.324	1.391
24	0.357	1.043	1.400	0.083	0.818	0.901
32	0.192	1.031	1.223	0.092	1.197	1.289
40		No sample			No sample	
48	0.622	0.464	1.086	0.103	1.204	1.307
56	0.541	0.135	0.676	0.099	1.097	1.196
64	0.409	0.009	0.418	0.089	0.964	1.053

The percentage of sulphur found on a basis of ignited ware is given in Table II and these results are also shown by curves in Fig. 10.

Discussion of Draw-Trial Analyses

Water-Soluble Sulphur

The analyses of skin samples of draw trials from 4 feet up in the kiln illustrates clearly the two processes of gas absorption. At 16 hours the amount of water-soluble sulphur is great owing to the sulphurous acid held in solution by the hygroscopic water. At 24 hours, even though this water was not expelled, the solubility of SO_2 in it had been diminished by the increase in temperature. This increase in temperature, however, increased the tendency to form ferric sulphate, so that the amount of water-soluble sulphur increased again until the temperature was so high that it drove off first the free sulphuric acid and then that combined as ferric sulphate. This decomposition was nearly completed in 64 hours. The surface of the ware at the bottom of the kiln shows the same course of events, but taking place more slowly and not going to completion.

Samples from the hearts of the brick show a gradual increase to a smaller maximum, and then decrease again. Once the sulphur gases had penetrated the ware they were more easily retained there, and were converted from the acid condition to ferric sulphate.

Acid-Soluble Sulphur

It would appear from these results that the pyritic content of the clay was very irregular. No theory of kiln absorption of sulphur has been advanced by which there might be formed during firing a compound insoluble in water but soluble in dilute aqua regia. Such a reaction is un-

reasonable. However, the results diverge unreasonably. The 14 analyses made from samples fired for 32 hours or less show a minimum of 0.813% of sulphur, and a maximum of 1.559%; the average is 1.080%. It is, therefore, probable that the distribution of pyrite is very irregular.

Half-way down the kiln the pyrite was all burned out of the surface of the ware well before the test was completed, and almost entirely out of the middle of the ware by the end of the test. The decomposition of pyrite on the surface of the ware on the floor of the kiln was finished, but decomposition of pyrite at the center of the kiln hardly begun.

Summary

The results of these four kiln studies may be summarized as follows:

1. A considerable proportion of the volatile sulphur from the coal used is absorbed by the ware as it passes through the kiln until a temperature of about 1400°F is reached. This absorption takes place in different ways, as the temperature rises as follows:

(*a*) Sulphur dioxide is absorbed by surface moisture on the ware as H_2SO_3, up to 212°F; after which H_2SO_3 is decomposed.

(*b*) Sulphur trioxide is absorbed by surface moisture on the ware as H_2SO_4. The H_2SO_4 attacks the accessory minerals, especially the lime and iron. This absorption ceases at 212°F, but the H_2SO_4 is not decomposed by heat until about 500°F is reached.

(*c*) Ferric sulphate is formed throughout the ware at temperatures up to 1100°F by the action on free ferric oxide in the ware of either absorbed acid solution or kiln gases.

(*d*) Sulphur is locked in the clay in an insoluble form, possibly as a sulpho-silicate, at all temperatures up to 1300°F under conditions favorable to such action.

2. Sulphur is evolved from the kiln and passes off up the stack from the following causes:

(*a*) Sulphur gases from the coal not absorbed by the ware. (The ratio of SO_2 to SO_3 may be changed by the catalytic action of the hot clay as the gas passes through the kiln.)

(*b*) Sulphur dioxide from H_2SO_3 at 212°F and breaking down of any sulphites temporarily formed.

(*c*) Vaporization and breaking down of H_2SO_4 at about 500°F.

(*d*) Decomposition of pyrite and associated minerals. This is often the main source of sulphur in stack gases after (*a*) above. This begins at about 800°F, and takes place vigorously.

(*e*) Decomposition of ferric sulphate. This gives off the bulk of its gas between 1040° and 1427°F.

(*f*) Decomposition of ferrous sulpho-silicate probably beginning at about 1300°F.

3. Evolution of sulphur may be temporarily suspended by the ignition of carbon in the kiln, which is often brought about by the burning pyrite. The carbon in burning will retard the oxidation of pyrite until the former is nearly all burned out.

4. A core may be formed in partly fired ware when pyrite is burned out on the surface, but remains at the center. This core disappears on further firing.

5. A different core may be formed by too rapid firing. If there is much permanently combined sulphur (sulpho-silicate) present, and the ware loses much of its porosity on the surface before the sulphur is all decomposed, SO_2 and SO_3 will be unable to escape as fast as generated, and will set up a pressure. This will swell the ware. Ferrous silicate will then melt to a black mass, full of blebs, at the center, although the surface of the ware may be the color of properly fired ware.

ACKNOWLEDGMENTS: Thanks are due to the managements of the various plants visited for the courtesies extended by them; also to E. E. Pressler of the Columbus Experiment Station for help in taking samples in the second investigation; to Robert Armstrong in the third investigation; and to the crew of the car "Holmes" in the fourth investigation.

THE LABORATORY TESTING OF ALUMINOUS REFRACTORIES[1]

By R. F. Geller

ABSTRACT

Eight brands of high alumina refractories and two brands of fire clay refractories, which are used by the trade under conditions of service requiring resistance to the corrosive action of lime and cement clinker at high temperatures, were subjected to standard and modified laboratory tests for high grade refractories. Data obtained indicate the results which may be expected in the technical examination of this type of product.

The great demand for refractories capable of meeting the increasing severity of furnace conditions, and the high cost of the so-called special refractories, have compelled manufacturers to focus their attention on the production of modified fire clay refractories to obtain from them the very highest efficiency consistent with their inherent physical and chemical properties. For certain types of service this has resulted in the rapidly increasing use of high alumina or bauxitic materials.

Since the literature contains very little data on the laboratory testing of refractories containing fifty per cent or more of alumina, a preliminary investigation was carried out at the Bureau of Standards on a limited number of brands to find out the behavior of such materials when subjected to standard and modified tests.

Complying with a request from the Bureau, five manufacturers submitted shapes used in the lining of rotary cement kilns. These samples, representing two brands of fire clay refractories and eight brands of aluminous refractories, were subjected to the following tests: A. Softening point; B Constant volume; C. Quenching; D. Absorption; E. Deformation under load; F. Slagging.

Method of Testing

Softening Point The softening points were determined in an electrically heated muffle and measured by means of Orton pyrometric cones.

Constant Volume The constant volume test was made by heating test pieces at 1400°C for five hours and measuring the resultant change in linear dimensions. Five test pieces[2] of each brand were used in this test.

Quenching The quenching test was conducted on brick which had been reheated at 1400°C for five hours. The quenching itself followed in principle the tentative A. S. T. M. method. It was carried out by heating the brick at one end to 850°C in a kiln door

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce. Received Jan. 28, 1924.

[2] The test pieces were sawed from the shapes submitted and approximated the size and shape of nine-inch brick.

and plunging the hot end into a bath of running water to a depth of four and one-half inches. The brick were allowed to remain in the water for three minutes, taken out, allowed to steam in the air for five minutes, and then returned to the kiln door. This was repeated in hourly cycles until the end had entirely spalled off. Five test pieces[1] of each brand were quenched.

Absorption The absorption was determined on the material as received and also on the test pieces which had been reheated at 1400°C for five hours. The following formula was used:

$$\text{Per cent absorption} = \frac{\text{Saturated weight} - \text{Dry weight}}{\text{Dry weight}} .100$$

Deformation Under Load Several load tests were made in accordance with the A. S. T. M. standard method, but the results showed uniformly high resistance to deformation. The test was, therefore, made considerably more severe by holding the test pieces at 1450°C for one and one-half hours under a load of forty pounds per square inch. This modified test, as the data in Table II show, was conducted on test pieces[1] as received and on test pieces[1] which had been reheated at the Bureau at 1400°C for five hours.

Slagging The slag test was made in two ways:

1. A heavy cardboard cylinder one inch high and two inches in diameter was placed on the upper face of a test piece[1] laid flat and the cylinder was filled level full with cement clinker ground to pass a 100-mesh screen. The test set was then placed in the furnace, heated to 1400°C and held at this temperature for five hours. The resistance to slagging was determined by visual inspection.

2. Cones were prepared of mixtures of equal parts of the refractory to be tested and of the clinker. Both were ground to pass an 80-mesh screen. The softening points of the mixtures were then determined according to the A. S. T. M. standard method.

Results

The data obtained from these tests indicated that the refractories submitted belonged to three well defined groups. Figure 1 and Table I have been so arranged as to emphasize this grouping.

Softening Point The data show a close relation between alumina content and softening point and, as is to be expected from the nature of the SiO_2-Al_2O_3 softening point diagram, the refractoriness increases rapidly with increase of Al_2O_3 in this range of compositions.

[1] The test pieces were sawed from the shapes submitted and approximated the size and shape of nine-inch brick.

TABLE I

Type of test	Specimens containing 40–45% Al_2O_3		Specimens containing 50–55% Al_2O_3		Specimens containing 70–85% Al_2O_3	
	Body no.	Results	Body no.	Results	Body no.	Results
Softening point	8	29	2	34	1	39
	9	30	4	34	3	37
Results given in cones			6	34	5	36
			11	34	12	37
Average		29+		34		37
Quenching test	8	6	2	8	1	50+
Results given as number of quenchings required to produce failure	9	3	4	22	3	19
			6	50+	5	19
			11	50+	12	40
Average		4.5		32+		32+
Per cent absorption after reheating at 1400°C for 5 hours	8	6%	2	14%	1	19%
	9	6%	4	14%	3	15%
			6	13%	5	14%
			11	15%	12	20%
Average		6%		14%		17%
Resistance to slagging	8	4	2	6	1	10
Results given in cones as softening points of 50–50 clay-clinker mixture	9	4	4	6	3	14
			6	6	5	14
			11	6	12	14
Average		4		6		13
Load test	8	Failed	2	3.7%	1	2.7%
Results given as per cent deformation under a load of 40 lbs. per sq. in. after heating at 1450°C for $1^1/_2$ hours	9	Failed	4	4.5%	3	Failed
			6	7.0%	5	Failed
			11	4.8%	12	5.7%
Average				4.5%		4.2%
Constant volume	8	+0.1%	2	+0.2%	1	+0.3%
Results given as per cent linear change after reheating at 1400°C	9	+0.1%	4	+0.5%	3	−0.3%
		Note:	6	−0.1%	5	−0.1%
		both over-fired	11	−0.2%	12	+0.1%
Average		+0.1%		+0.1%		0.00

With the exception of bodies 8 and 9, which are not, strictly speaking, in the class of aluminous refractories, the softening points are well above those of fire clay refractories intended for high heat duty and a softening point of cone 34 would apparently be a reasonable specification for the product considered in this investigation.

Constant Volume The uniformity of results obtained by means of the constant volume test for the ten brands examined, given in Table II, indicate that this test has very little if any value as a method for the determination of the relative qualities of high alumina refractories.

Quenching In the quenching test, bodies 8 and 9 which are relatively low in alumina (see Fig. 1 and Table I) showed poor resistance to spalling as compared with those containing from 50 to 85%. In the latter group the results do not show the close relation between softening point, chemical composition and resistance to thermal shock which was previously obtained with fire clay refractories.[1] This may be explained by considering the volume changes of free silica during heating and cooling[2] which, as is generally accepted, materially affect the ability of a refractory to withstand changes in temperature through the ranges in which these changes take place. If, therefore, all or practically all of the silica is combined with alumina in the finished product, these volume changes will no longer be the predominating factors affecting resistance to spalling and the influence of such factors as porosity, mechanical strength and structure become more pronounced. These in turn can be controlled by workmanship and method of manufacture.

TABLE II

Body no.	Per cent linear change in constant volume test	Per cent absorption as received	Per cent absorption after reheating	Per cent deformation under load as received	Per cent deformation under load after reheating	Per cent Al_2O_3 (data furnished by manuf.)
1	+0.3	18	19	2.64	2.0	70–75
2	+0.2	15	14	3.71	12.2	50–55
3	−0.3	15	15	Failed[1]	Failed[1]	80–85
4	+0.5	14	14	4.5	3.7	55
5	−0.1	14	14	Failed[1]	Failed[1]	75
6	−0.1	13	13	7.0	5.7	50
8	+0.1	9	6	Failed	Failed	40
9	+0.1	7	6	Failed	Failed	40
11	−0.2	13	15	4.81	4.01	50
12	+0.1	20	20	5.76	5.16	75

[1] Not characteristic load test failures.

The data on quenching (Table II) also show that wide variation in results was obtained with the bodies containing from 50 to 85 % alumina. Sample 2 failed after eight quenchings, while samples 1, 6 and 11 showed no indications of failure after fifty quenchings. There are no reasons evident for this, but it is quite probable that information of interest and

[1] R. F. Geller, "Progress Report on Specifications for Refractories," *Jour. Amer. Ceram. Soc.*, **6** [10], 1098–1111 (1923).

[2] α-quartz to β-quartz at 575°C; α-cristobalite to β-cristobalite at 230°C.

value could be obtained through a detailed study of the raw materials and methods of manufacture involved.

Absorption The complete absorption data are given in Table II. It is evident that reheating had very little effect on the absorption and in several cases no change could be determined by the method employed. For this reason only one set of results were plotted in Fig. 1. The lower refractory bodies (8 and 9) were comparatively dense and the structure after reheating showed evidence of the formation of glass, while the bodies of higher refractoriness were on the average, higher in absorption, but there is not sufficient difference between these and the bodies of average alumina content to be of significance. It is doubtful if any specifications based on absorption would be of value.

Load Probably the most important result of the load test work is the fact that the A. S. T. M. standard method requiring satisfactory resistance to a load of 25 pounds per square inch at a temperature of 1350°C for one and one-half hours was shown to be not sufficiently severe to produce good comparative data. For example, there was practically no difference in the amount of deformation of bodies 1 and 8, although most of the other tests of the series indicated a considerable difference between these two materials. This is not at all surprising since it is well known to manufacturers of refractories that a brick of many inferior qualities can be so made as to withstand satisfactorily the test for deformation under load at high temperatures. Accordingly, the temperature requirement was raised to 1450°C and the load to 40 pounds per square inch.

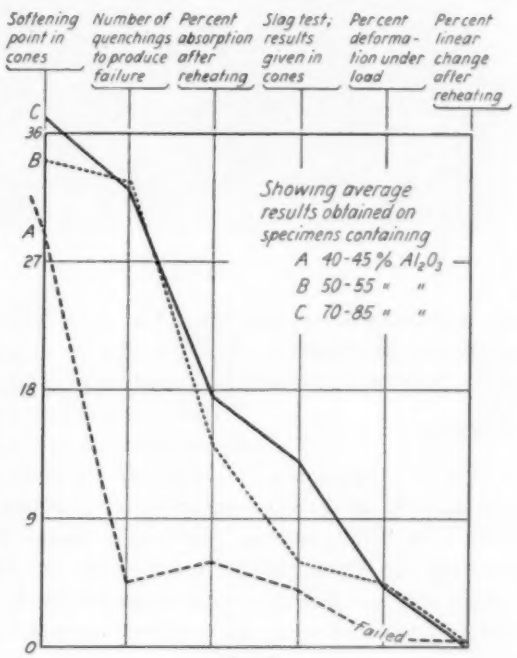

FIG. 1.

Table II shows that (with the exception of body 2 which also showed especially poor resistance in the quenching test) reheating had no noteworthy effect on the deformation of the test pieces[1] and only test results

[1] *Loc. cit.*

on material as received were plotted in Fig. 1. Brands 3 and 5 sheared under a load of forty pounds per square inch before the maximum temperature (1450°C) had been reached, but the appearance of the tested specimens would indicate that failure was due more to excessive load than to any appreciable lowering of viscosity in the material. Since resistance to a load of forty pounds per square inch is considerably greater than that of ordinary structural requirements, it is quite possible that these brands would not fail in service although their structure would undoubtedly be weakened at high temperatures. For this reason a further modification of the test, reducing the load to twenty-five pounds per square inch while retaining the temperature and time requirements of 1450°C and one and one-half hours, respectively, is recommended.

Lack of material prevented repeating the work, but it would seem reasonable to assume that such a test would eliminate the product which is sold to resist load and slag action at high temperatures, but which would

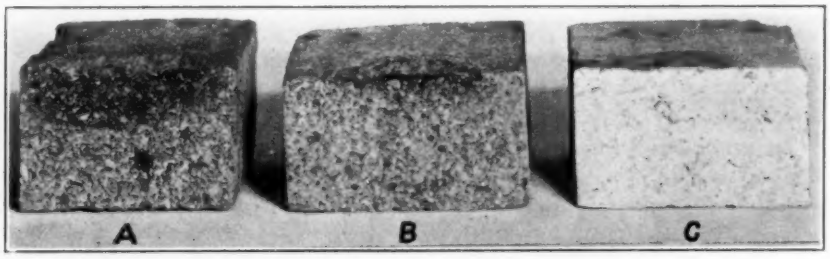

FIG. 2.

not give satisfactory service. The data further indicate that a maximum allowable deformation of 5% would be a liberal specification, although more information would be required to determine definitely this value.

Slagging

Typical results of the slagging test, conducted according to the first method described, are shown in Fig. 2. Specimen A (Body 9) contained from 40 to 45% alumina, specimen B (Body 11) from 50 to 55% alumina, and specimen C (Body 1) from 70 to 85% alumina. Although the results permit of easy comparison between the three groups, there being, for example, considerable fluxing action and penetration of slag in the case of A while C remained unaffected, the fact remains that the evidence obtained cannot be so interpreted as to show numerically the relative resistance to slagging.

For this reason the work was duplicated, using the second method. The results obtained (Table I and Fig. 1) seem to warrant consideration because: A, the values can be duplicated and are consistent with variations in alumina content; B, the test can be standardized; C, it affords a numerical ratio upon which a specification can be based.

Summary

The data obtained, as summarized graphically in Fig. 1, would indicate that with refractories of the aluminous type containing 50% or more alumina, the following results may be expected from laboratory tests:

1. The softening point will be equal to, or exceed, that of the Orton standard pyrometric cone 34.
2. The constant volume test will not produce results of value.
3. The refractory will withstand eighteen or more quenchings without failure.
4. The absorption, while generally higher than for refractories containing less than 50% alumina, would not be satisfactory for specification work.
5. The deformation will not exceed 5% when using a load of twenty-five pounds per square inch and a maximum temperature of 1450°C.
6. The softening point of a mixture of equal parts of refractory and cement clinker is equal to, or exceeds, that of the Orton standard pyrometric cone 6. This test would, of course, apply only to material intended for service requiring resistance to the slagging action of cement clinker.

SOME CONSIDERATIONS NECESSARY IN SELECTION OF REFRACTORIES FOR THE OPEN HEARTH[1]

By Sidney Cornell

ABSTRACT

The kind, quality and quantity of refractory brick used in steel plant furnaces, coke ovens, blast furnace, open hearth and auxiliaries are discussed.

The factors that influence the life of refractory brick in the open hearth furnace, discussed numerically, with the economic situation indicated in monetary value.

The Situation in General

Improper selection of kind and quality, and to a certain extent quantity of refractories has been the theme of more than one paper presented before the American Ceramic Society. Complaint has been made that failures are largely the consumer's own fault, and due to the fact that the refractories manufacturer is not given accurate and detailed analysis of actual conditions to which his product will be exposed.

The steel manufacturer will not or cannot place the desired information in the hands of the refractories manufacturer. There are several reasons, some of the most important of which will here be indicated. It behooves the refractories manufacturer to get the facts. Fortunately this is not as difficult an undertaking as might be supposed. Coördination of all facts is a difficult task. The large and important technical facts on refractories contributed by the Bureaus of Standards and Mines, the Mellon Institute, etc., in the past five or six years are but part of the consideration necessary. There are parallel situations existing in a number of different industries. Consideration of these situations should be of material aid.

A number of important improvements in metallurgical practices await improvement in refractory materials. The metallurgist cannot or will not clearly indicate to the ceramist just what to do or how to improve his products. This probably is due to the fact that metallurgists do not understand clays, etc. There are a number of refractories on the market which in their performance are excellent. On small apparatus, and on chemical engineering apparatus they are used with marked satisfaction, but for large furnace work their cost is prohibitive. If only a few thousand brick are required for a kiln, and oven, a fire box, or for small electric furnace linings, this high cost is of no great consideration.

An open hearth has 1,000,000 brick in it. Chrome and magnesite brick have been used for the past twenty years. It is all well and good to say and to know that chrome brick will stand up well under conditions where silica or magnesite will spall away 25%. Chrome brick cost today $210.00 per M ($45 net ton), whereas ten years ago they cost $110 per M. Our standard open hearth, if made of all chrome brick, would come to $200,000 for brick alone. First, second and third quality fire-clay brick, silica brick

[1] Presented at the Atlantic City Meeting, Feb., 1924 (Refractories Division).

magnesite and chrome brick all have their specific places in an open hearth. They are used because no better material has been proven.

Consider the industries where forging furnaces, annealing furnaces, carbonizing, hardening and draw-back furnaces, either muffle, direct, continuous, automatic or semi-automatic are used. The refractories in such are not exposed to the same exacting conditions found in melting furnace, blast furnace, open hearth, electric furnace or Bessemer. While some betterment is still possible in these heat treating furnaces, as a rule their life is long. Once built they stay built. From a refractories standpoint the open hearth is rebuilt at least once yearly, and the blast furnace which should have produced 1,000,000 tons per lining, is rebuilt once in five or six years. Coke ovens have lasted as long as 20 years, although this is exceptional.

It is generally believed that refractories fail because they shrink and spall, not because they melt. This is begging the subject. We can expect refractories to meet present conditions only by knowing the conditions to be met, by a complete and thorough study of all conditions, consideration being given to economic conditions, costs, etc.

No open hearth furnace is going to be built from chrome brick alone at a cost of $200,000 for brick. Some of the excellent refractories obtainable cost many times more than chrome brick. Common brick at $22, 1st quality clay refractories at $42, silica at $40, chrome at $210, and magnesite nearly $300 per thousand are used as experience has proven the economies in the use of each.

The open hearth furnaces use several fuels, natural gas, producer gas, coke oven gas, oil or tar and powdered coal. Powdered coal would be an economy if refractories were obtainable that would withstand its use. Coke oven gas cannot be burned as cheaply as producer gas because of the limitations of refractories. Powdered coal is an economic failure in open hearth work today simply because of the failure of the refractories.

The Life of Refractories

An open hearth is operated so that two heats per day are gotten out of it. Naturally if three heats are possible they are run. Sunday practice makes use of a soaker heat, charging cold pig. An open hearth roof is estimated to last 250 heats, and checkers on producer gas 500 heats. Thus a furnace turning out 11 or 12 heats per week has a roof life of 20 weeks. A new roof is then built. It commonly requires one week to replace the first roof, and two weeks to make the rebuilding, a loss of three weeks in time, and a production of 3600 tons of steel. While 250 heats per roof are looked for, this is not always attained.

The consumption of refractories in an open hearth depends largely upon the fuel used. The following are estimated lives:

Life of checkers on natural gas 1000 heats, producer gas 500, oil 500 and powdered coal 250.

Industrial Requirements

A comparison with other steel plant apparatus is desirable for a complete understanding of the overall situation as affecting open hearth refractories.

Coke Ovens Generally satisfactory. Extremes are found in old original Koppers by-product coke oven construction, dating back to 1909–10, and the Semet-Solvay, whose ovens have lasted as long as 20 years in operation.

Koppers by-product ovens require 20 tons structural steel per oven, 150 cu. yds. concrete, 35,000 brick, 190 shapes and sizes of silica brick and 50 shapes and sizes of fire-clay brick.

Semet-Solvay by-product ovens require 26 shapes and sizes of silica brick and 9 shapes and sizes of fire-clay brick.

Blast Furnaces Generally satisfactory. Records of high production on a lining easily obtainable. Records of failure more difficult to locate. The failures probably yield more data than average performance records. Standard 500–600-ton furnace, 14′ hearth, 10′ well, 21′ × 13′ bosh, stock line 15′, stack proper 45′. Hearth 1700 cu. ft., bosh 3300 cu. ft., stack 12,000 cu. ft.

BLAST FURNACE BRICK

	Number of shapes and sizes	Number of pieces
Hearth and bosh	9	55,000
Inwall	4	135,000
Top and gas arch	10	50,000

Total, 23 shapes and sizes, 3 qualities and 240,000 pieces. In 9-inch equivalents, this will total 500,000 brick.

Blast Furnace Stove, McClure Type One stove contains 38 shapes and sizes, 50,499 pieces, 1st quality clay, and 40 shapes and sizes, 89,690 pieces, 2nd quality clay brick.

The four stoves to a furnace thus contain 78 shapes and sizes, 2 qualities and 560,000 brick.

A blast furnace as iron producing apparatus contains 100 shapes and sizes, 5 qualities of brick, 800,000 individual pieces, and which in 9-inch equivalents totals 1,500,000 brick.

It is the practice when specifying a lining to add 5% to net count for losses in building. This in itself is a high requirement and should be unnecessary. It is the practice of (H. & W.), one well-known refractories manufacturer, to stamp brick for hearth H, for inwall I, and for top T. This practice should be adopted for open hearth brick,

A single open hearth furnace has as many brick in its structure as a blast furnace, a fact not often appreciated.

As an example of failure: Duquesne No. 5 was blown in on March 16, 1909, and out August 24, 1910, having made approximately 200,000 tons of iron. The last word in engineering was put into that furnace, but it did not come out. Why did the furnace fail? What did the brickmakers learn from this failure? There are many records of 1,000,000 tons production on a lining.

The Open Hearth A furnace can be assumed to contain some 300 tons of structural steel in its pan, binding, crane runways, etc.

Natural gas, basic bottom 80-ton-furnace contains:

	Number of shapes and sizes	Number of pieces
Silica brick	26	141,000
Magnesite brick	3	20,000
First quality clay brick	16	250,000
Third quality clay brick	7	84,000
Common brick	1	350,000
Grain magnesite	80 tons	

In such a furnace there are five grades of brick, 53 shapes and sizes and 845,000 individual pieces. In 9-inch equivalents this will total over 1,500,000, equal to the brickwork of a blast furnace and stoves.

Five grades of brick are required in its structure. Considering the work it has to perform these seem too few.

Producer gas, acid bottom 80-ton furnace contains:

	Number of shapes and sizes	Number of pieces
Silica brick	20	197,000
1st quality clay brick	16	250,000
3rd quality clay brick	7	84,000
Producer (2) and gas mains	7	40,000
Common brick		350,000
Bottom sand	25 tons	

In such a furnace there are 5 grades of brick, 50 shapes and sizes and 921,000 individual pieces.

The auxiliaries in connection with the open-hearth furnace are relatively simple in refractory requirements.

A metal mixer will use 2nd quality fire-clay brick for its lining, using 24 shapes and sizes and 50,000 pieces.

Calcining cupolas will utilize 1st quality fire-clay brick, some common brick using 3 shapes and sizes and 10,000 pieces.

Ladles utilize ladle brick, a 60-ton taking 2700 pieces, and an 80-ton, 3500.

Refractories Requirements of Open Hearth vs. Blast Furnace

In round numbers the blast furnace consumes one brick per ton of iron made. In round numbers the open hearth consumes three brick per ton of steel made when on natural gas; 5 to 6 brick per ton of steel made when on producer gas; 8 to 12 brick per ton of steel when on powdered coal.

A production of 1,000,000 tons of open hearth steel using natural gas as fuel and the easiest on brick represents:

Expenditures	
Material other than brick.....	$ 25,000
Brick.....	160,000
Labor.....	115.000
	$300,000

It may be roughly stated that it cost $.30 per ton of steel for refractories using natural gas as fuel, $.60 using producer gas, and $1.20 per ton using powdered coal.

A blast furnace producing 1,000,000 tons of iron may require $.15 per ton of iron for rebuilding. If, however, a blast furnace fails as did Duquesne No. 5, the refractory cost will jump five times, namely to $.75.

With an open hearth roof which is expected to last 250 heats, if the performance is 80 heats to a roof, and 125 heats the final performance, the normal cost climbs from $.30 to dollars per ton of steel made. It is not to be wondered that the steel metallurgists are complaining.

Chrome brick was mentioned but was not listed in open hearth construction. Chromite brick during the war and immediately thereafter became so unsatisfactory that open hearth builders found that it was not necessary to separate magnesite from silica. A great loss of chrome brick business resulted. Poor quality of home ores may have been the reason. The merits of good chrome brick, non-sticking, non-melting, hot-patch merits, resistance to spalling, are known and advertised. Ten times the life of silica is a broad statement. On a cost to cost basis it must be $40 to $210 to start with, or 1 to 5.

Performance of Refractories

Complaint has been made that the steel manufacturers do not keep records of performance of refractories. Ten years ago practically every master mason in a steel plant kept or attempted to keep card records covering receipt of brick, shed location, in and out record, placement in furnace, etc. This is no mean job of accounting or of clerical work. The steel business is peculiar when it comes to recording. The modern automobile shop, taken as representative of specialized manufacture, has a planning, a cost and an inspection department, which function in a way impossible, so it seems, in a steel plant. High grade clerks, properly paid,

are employed in the automobile shop. As a rule the clerk given to a master mason, in a steel plant, especially if his own selection, is a bright young bricklayer, more interested in laying brick than in keeping records. If an honest-to-goodness clerk is employed, his pay is small, comparatively speaking. Here and there, there are reliable refractories records. Usually when they exist, because of their merit, and the steel works management refrains from disclosing them to Tom, Dick and Harry.

The refractories manufacturer must make it easier to record refractories. Stamping of "hearth," "bosh," "inwall" and "top" on the brick would help materially. Open hearth brick might be stamped "roof," "checker," "neck" and with a code letter, heat number, etc. A sufficient number of brick will probably be salvaged with identification marks so that records of their life could be had.

Whereas the automobile industry is well equipped with cost, production and inspection clerks, and likewise with competent metallurgists, the steel business is deficient in them. Perhaps unnecessary importance is attached to steel works cost records such as they are. This may explain why the steel plant management has so reluctantly given out refractory performance. As an example of this situation, and one that contributes some information on refractories, the following is representative:

A well known steel plant has 24 50-ton open hearth furnaces, using natural gas as fuel. 16,788 heats were made in 12 months.

Classed as refractories are magnesite, dolomite, chrome ore, loam, clay and coke, a total of 50,000 tons of these materials being used annually. Indirectly the performance of the refractory brick influences this consumption. In the year, 1,000,000 ladle brick, 19,000 stopper, 200,000 sleeve and 19,250 nozzle brick were used, which are not influenced by the performance of the furnace brickwork.

During the year 80 repairs were made to the furnaces. A repair is either a new roof, or a complete rebuilding.

In the record, one of the furnaces lasted only 79 heats and the roof was gone, whereas another furnace lasted 318 heats on a roof. The average for the 24 furnaces was 189 heats per roof. The question all would like to be able to answer is why did one furnace last 79 heats and another 318. Four furnaces in this plant did better than 250 heats per roof, while five furnaces approximated but 150 heats.

In making the 80 repairs to the 24 furnaces, the following brick were used:

Silica	2,520,126
Magnesite	98,773
Clay	547,739

The value of this brick is not the only element to consider. Lumber will cost from $12,000 to $15,000 annually. Bolts, castings and other

finished material will total $15,000, and there will be a scrap allowance or credit of $5,000 for the discarded, worn out castings, etc. There is thus $25,000 worth of materials per annum required other than brick.

Labor for rebuilding the above furnace is as follows:

	Hours
Open hearth and common labor	170,000
Bricklayers	20,000
Carpenters	7,000
Boilermakers	4,000
Total	201,000
	2,500 per repair.

Overhead, based on labor, would enhance this figure materially.

The loss of production is serious. Fifteen days operation is lost per furnace per annum, these being natural gas furnaces. On producer gas-fired furnaces, the lost time would be 20 days. There being 24 furnaces in this plant, and $24 \times 15 = 360$, the situation is that one furnace in this plant is never at work. As the annual tonnage is 1,000,000 tons of steel, there is a dead loss of 40,000 tons of steel due to rebuilding, and the fact that the open hearth is not a permanent structure. There is lost tonnage due to waiting on materials, charging machine, bad bottom, etc., which totals 40,000 tons. An annual loss of 80,000 tons of steel valued at $25 a ton means a $2,000,000 loss. Better refractories would probably have saved $^1/_4$ of this, or $500,000.

Refractories for Powdered Coal

The performance of powdered coal is quite conclusive after a period of seven years' service in one plant. The condition of powdered coal fired furnaces after 100 heats was worse than the condition of similar furnaces oil fired after 287 heats. Incidentally, gas fired furnaces in this same plant suffered even less than the oil. In the powdered coal fired furnace, the refractories cut away, the slag pockets fill faster and the checkers become choked. The general overall condition cannot be entirely attributed to the ash that naturally is present in powdered coal. A coöperative study of this method of utilizing fuel must be made.

Open Hearth Furnace Design

Open hearth furnace design is far from uniform. Furnaces in different plants, and in some cases existing in the same plant, of the same rated capacity melting the same size heat will vary in width, length, volume of checkers, etc. These variations cause radically different velocities in the different parts of the furnaces.

The Carnegie Steel Company has adopted standard practices for open hearth. These standards are:

(1) Fuel: Producer Gas: Producers 2 per furnace, each producer to gasify 60,000 lbs. of coal per day, *i. e.*, the 2 gasify 5000 lbs. per hr.

(2) Capacity of Furnace: 100 tons; bath area 650 sq. ft. at the slag line.

(3) Bottom: Pan type, with 12″ sintered magnesite on 12″ magnesite brick on 24″ fire-clay brick.

(4) Roof: Body straight arched in one direction only with 24″ spring. Roof thickness to be 12″. Only standard shapes to be used.

(5) Doors and Frames: Water cooled, doors electrically operated.

(6) Buckstays: Slab type, water cooled.

(7) Front and Back Walls: Supported on water-cooled coolers at the slag line.

(8) Ports: Semi-water cooled type, cooled at vital points.

(9) Bulkhead: Water cooled.

(10) Air Regenerators: Minimum 68 cu. ft. per ton with minimum 150 square feet of surface per ton. 6,800 cu. ft. and 15,000 sq. ft. standard for 100 ton.

(11) Gas Regenerators: Minimum 46 cu. ft. per ton, with minimum 100 square feet of surface per ton. 4600 cu. ft. and 10,000 sq. ft. standard for 100 ton.

(12) Valves: Area of gas and air valves 10 sq. ft. each.

(13) Damper: Cast iron, inclined and air cooled.

(14) Stack: 6 ft. in diameter, 180 ft. high.

(15) Waste heat boilers to be considered as standard equipment.

With this standard in mind, it is interesting to compare other open hearth furnace dimensions. As the standard 100 ton furnace of the Carnegie Steel Company cannot be so taken for the entire industry, it is necessary to compare furnaces of different capacities. This is done in the following tables.

The lack of agreement in major dimensions causes each open hearth furnace installation to be a study unto itself. How seriously this affects the brickwork may be judged by considering the velocities encountered. In this case a set of eight open hearth furnaces whose standards approach that of the Carnegie Steel Company are taken to make the estimations.

Good steam engineering practice is to hold the velocity of steam in a pipe to a mile a minute, that is 5000 feet per minute, which is a gale of wind figured in ordinary standards at 60 miles per hour. Burning gases pass through various parts of an open hearth furnace at this velocity, cyclonic in speed, capable of carrying a substantial quantity of material in its current.

Producer gas weight .07111 per cu. ft., air .0765 and flue gases .0872. A 100 ton furnace utilizes 350,000 cu. ft. producer gas per hour, or 6000 cubic feet per minute. 1 cu. ft. producer gas requires 2.8 cu. ft. air and makes 3.5 cu. ft. flue gas. 1 lb. producer gas requires 3 lbs. air and makes 4.25 lbs. of flue gas, the addition to the flue gases representing leakage, etc.

The velocities through a 100-ton furnace approximate the following. A gas expands one volume for each increase of 500°F. Thus the 6000 cu.

TABLE I—COMPARISON OF DIMENSIONS OF OPEN HEARTHS OF DIFFERENT CAPACITIES

Capacity	200	100	60	50	40	20
Hearth length	40′0″	39′8″	36′0″	27′0″	34′0″	22′0″
Hearth width	14′6″	15′0″	13′6″	14′0″	13′0″	12′0″
Sq. ft./ton	2.9	3.9	8.1	7.5	11.0	13.2
Cu. ft. gas. reg.	5786	3912	1455	1122	1787	909
Cu. ft. / ton	28.9	26.1	24.3	22.4	44.7	45.4
Cu. ft. air reg.	7612	6685	1905	1870	2501	1187
Cu. ft./ton	38.1	44.5	31.8	37.4	62.5	59.3
Gas uptake	1800 s″	1296	960	1740	2658	576
Air uptake	3600 s″	2160	1566	2016	3294	702
Gas port	5.4 sf	3.1	6.6	9.0	2.9	2.0
Air port	15.8 sf	14.0	10.4	13.5	13.5	3.0
Gas valve	42″	42″	42″	42″	42″	27″
Air valve	48″	32″	48″	42″	48″	27″
Chimney	6′0″ × 130′	6′ × 120′	7′ × 140′	6′ × 150′	5′6″ × 140′	3′6″ × 120′

TABLE II—COMPARISON OF DIMENSIONS OF OPEN HEARTH FURNACES OF 50 TONS CAPACITY

Capacity	50	50	50	50	50
Length	32′0″	27′0″	34′0″	29′0″	31′0″
Width	13′0″	14′0″	12′8″	16′0″	13′0″
Sq. ft./ton	8.3	7.5	8.6	9.3	10
Gas regenerator	23 × 12 × 9	22 × 6 × 9	24 × 7 × 14	17 × 10 × 14	.....
Cu. ft.	2397	1122	2401	2485	.....
Air regenerator	35 × 12 × 9	22 × 10 × 9	24 × 11 × 14	17 × 12 × 14	12 × 12 × 14
Cu. ft.	3421	1870	3687	2979	2640
Gas reg. cf. ton	47	22	48	50	.....
Air reg. cf. ton	68	37	73	59	66
Gas port area	9	.....	7.6	.....	4.5
Air port area	13.5	.....	7.0	.....	10.8

ft. of producer gas measured at 60°F, expands at 1100°F, two volumes, *viz.* 3 times 6000, or 18,000 cu. ft. at 1100°.

COMPARISON OF GAS VELOCITIES IN OPEN HEARTH

Part of furnace	Area sq. ft.	Temperature, Deg. F	Volume of gas, cu. ft.	Velocity, Feet per min.
Gas Valve	10	1100	18000	1800
Gas Entry Regenerator	30	1100	18000	600
Gas Regenerator Max.	157	2100	30000	200
Checkers Cross	97	2100	30000	310
Gas Take Off	20	2100	30000	1500
Gas Uptake	14	2100	30000	2200
Gas Port Top	8	2100	30000	3800
Gas Port Lip	6	2100	30000	5000
Air Valve	10	100	17000	1700
Air Entry Regenerator	47	100	17000	360
Air Regenerator Max.	257	2000	85000	330
Checkers Cross	162	2000	85000	520
Air Take Off	28	2000	85000	3000
Air Uptake (2)	25	2000	85000	3400
Air Port Top	42	2000	85000	2000

The flame temperature developed will approximate 4000°F. The 6000 cu. ft. of producer gas plus 17,000 cu. ft. air (total 23,000) expand to 9 times this volume, or 207,000 cu. ft.

The cross section of the hearth is 114 sq. ft., and an average velocity of 1750 feet per minute is attained. Friction of the walls and roof will cause counter currents, heat waves, and hot spot reflection from roof. Bath and walls cause interference. There is every probability that the gases in the hearth reach steam velocities that of 5000 feet per minute.

The 207,000 cu. ft. of gases at 4000 lose heat, contract and leave the hearth at approximately 3000°F, or slightly higher. A contraction to 150,000 cu. ft. seems reasonable, and it must pass through the gas and air ports on the opposite end of the furnace. In area the air represents 80%, hence 120,000 cu. ft. pass through it, and 30,000 cu. ft. through the gas port. The burned gases velocities then become:

Gas Port Lip	6	3000	30000	5000
Gas Port Top	8	3000	30000	3700
Gas Uptake	14	3000	30000	2100
Gas Take Off	20	3000	30000	1500
Gas Checkers	97	3000	30000	300
Gas Regenerator Max.	157	3000	30000	190
Air Port Lip	30	3000	120000	4000
Air Port Top	42	3000	120000	2800
Air Uptake	25	3000	120000	4800
Air Take Off	28	3000	120000	4300
Air Checkers	162	3000	120000	740
Air Checkers Max.	257	3000	120000	450

The gases are in some cases passed to a waste heat boiler but in the average case to the stack at 1000°. Flue gases being 3.5 times the volume of producer gas, mean 21,000 cu. ft. times 3 volumes for existing temperature or 63,000 cu. ft. per minute. The standard 6 foot stack, area 29 sq. ft., hence has gases passing through it at 2200 ft. per minute.

Due to the radical differences in design, proportioning of parts, etc., in open hearth furnaces, there will be different velocities encountered in each installation. Some are right, some are wrong; all cannot be right.

Enhancing the wear and tear of velocities are reversals. Water hammering in steam lines can break the pipe. The analogous effect in gas lines probably destroys brick. A quick closing of a valve in a high velocity water line will break the pipe. What is the effect of quick closing of open hearth valves on brickwork?

Approximately 500 reversals per week are the lot of an average open hearth. It seems impossible to regulate this operation mechanically, hence it is noted that the shortest period a regenerator may be on air or gas may be 2 minutes and the longest 70 minutes. The average may be 10 minutes, but the average time does not indicate the exact conditions.

An open-hearth furnace must melt and refine. This requires adjustment of temperature not recorded by a pyrometer. The latter is one of judgment and skill of the melter. On a two shift basis there are two first helpers. They are the melters. One takes the left hand end of a furnace, the other the right hand end. A bad end always develops. Jack favors his, and Jim his. What will happen on a three shift basis remains to be seen. In any event there is a human element present in which a bad end of a furnace gets worse, and reversals cannot be made a matter of mechanical refinement.

Little or no progress is being made in open hearth improvement, and the buck has been passed to the refractories man. He can take up the matter with profit to himself and to all concerned.

Velocities, reversals, a bad end, puff backs, minor explosions, scoring, slagging action, many enhanced by velocities seem to be the leads to follow on making better refractories.

The law of diminishing returns works on taxes. It also works on furnaces. A steam boiler operated at an overload furnishes steam at a marked economy in fuel. Carried to extremes a boiler is soon wrecked. The open hearth is also worked at an overload and at a marked saving in fuel. Thus a 50-ton furnace became a 60-, a 60- an 80-, and an 80- a 100-ton furnace. In many cases relatively few additions were made to get the larger capacity, and the overload shows itself in the brickwork. This is the situation viewed broadly. There is no reason why the experiences gained in operating at an overload should not be standardized. Who is going to do it?

Part of the procedure is the steel works initiative. Part of the procedure is the refractories manufacturers' initiative.

From 1880 to 1919, 14,281 boilers blew up, killing 10,000 people and injuring 17,000. The A. S. M. E. compiled a boiler code, and it has been adopted as law in 17 states. The results are apparent; accidents have been reduced. Overload caused these failures. Fortunately the open hearth does not blow up, but overload has caused increased expense, particularly in refractories.

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OPERATING CONDITIONS IN THE OPEN HEARTH AS THEY AFFECT REFRACTORIES[1]

By Clyde E. Williams[2]

In the open-hearth steel furnace, operating conditions and the life of refractories vary so much in different plants that it is dangerous to generalize and difficult to cover all phases of the problem. Acid and basic open-hearth furnaces differ mainly in hearth composition, that of the former being silica and of the latter magnesite. Acid practice is largely a melting operation and its refractory requirements are less severe than are those of basic practice. Moreover, less than 4% of the open-hearth steel produced in this country is made in the acid furnace. Hence, principal consideration will be given here to the basic open hearth.

Hearths

The hearth is subjected to severe action and must be repaired after every heat. Depressions and cracks are made during charging as a result both of the mechanical effect of the materials charged and of spalling due to changes in temperature. The siliceous hearth of the acid furnace is corroded during the melting stage by iron oxide formed by oxidation of the steel scrap and by that already present in the scrap. The banks are attacked by the slag, which, though siliceous, contains oxides of iron, manganese, and calcium. Acid open-hearth slags may contain 30 to 40% iron and manganese oxides and 2 or 3% lime.

The basic hearth is corroded by silica in the ore charged and by the slag, which, although strongly basic, contains sufficient silica to attack the magnesia lining. A typical basic slag contains 19% silica, 27% iron

[1] Published by permission of the Director, Bureau of Mines, Department of the Interior. Presented at the Atlantic City Meeting, Feb. 1924 (Refractories Division). Received in editorial office May 17, 1924.

[2] Superintendent, Northwest Experiment Station (Seattle, Wash.), Bureau of Mines, Department of the Interior.

and manganese oxides, and 52% calcium and magnesium oxides; the iron oxide content may be higher at the beginning of the heat and lower at the end. In addition to the action of the slag, a strongly corrosive silicate of iron and calcium is formed on the silica front and back walls by the action of the basic oxides carried by the furnace gas. This slag runs down and eats into the hearth at its point of contact with the brick walls. Were it not for this action the hearth material could be carried further up the front and back walls than is now done, resulting in protection of the walls from corrosion. A wall built of a refractory that would resist the fluxing action of the oxides of iron and calcium contained in the gas would decrease the hearth repairs now required for silica walls.

In repairing the basic hearth, calcined magnesite is placed in the larger depressions and either raw dolomite, calcined dolomite, or a prepared sintered dolomite containing iron oxide or ferruginous slag is added to the smaller holes. This operation requires much time and labor and also introduces to the furnace atmosphere basic oxides which may corrode the silica lining and help clog the checker work. In some plants an automatic machine using compressed air and a nozzle feeds the patching material where needed. A saving in time, labor and raw material is claimed, and, in addition, it is likely that, due to less dusting, a smaller amount of slagging substances is carried into the furnace atmosphere.

Walls, Roof, Ports and Bulkheads

Failure of the lining above the slag line is due principally to three effects: (1) fusion; (2) abrasion and slagging by the constituents of the furnace atmosphere, and (3) spalling and breaking.

Fusion of Lining The temperature of the steel must be raised to about 2900–3000°F. The furnace lining is as hot and usually is much hotter, and a flame temperature higher by at least 200°F is used. The pressure in the walls is not large and in the silica roof the load is in the neighborhood of 12 to 18 lb. per sq. in., depending upon the size and design of the furnace. The proper design of ports to produce a flame that will neither strike the roof, the side walls, nor the opposite end is essential to prevent rapid destruction of the furnace. Even with suitable design, it often happens that the port, unless water-cooled, wears away unevenly and prevents suitable control of the flame, causing more rapid destruction of the furnace lining. Although water-cooled ports produce a lower flame temperature and decrease the thermal efficiency, their use is justified so long as the present refractories, which are working at practically their maximum possible temperature, are used. Sometimes, careless operators may allow the flame to travel the entire length of the furnace and impinge against the brick work at the opposite end with disastrous results.

The desire to increase the furnace output by increasing the flame temperature causes more rapid melting away of the lining. Increased refractory cost must be balanced against profit obtained by larger output. Insulation of the roof, walls, and uptakes will give lower fuel consumption but will increase refractory cost. About 16% of the heat supplied to the furnace is lost by radiation and convection from the combustion chamber and port ends, and about 7% from the checkers and uptakes.[1] Hence, the saving of even a small proportion of this heat would represent an important fuel economy, in view of the fact that only about 16% of the heat supplied is used in producing steel. It seems highly probable that better refractories than silica brick, even at considerably greater cost, can be used profitably to permit the use of higher temperatures and to save heat now lost.

Abrasion and Slagging

The stream of gas passing through the furnace carries with it small particles picked up from the bath. These particles are thrown against the interior of the furnace abrading it after the nature of a sand-blast. This action is particularly severe at points in the furnace where the flame is forced against the lining as a result of piling the charge unevenly in the furnace, and at the ends where the gas stream meets the ports and bulkheads directly. These solid particles not only attack the lining by their physical abrading action, but they also become impregnated in the brick and form easily fusible compounds, which, naturally, are more concentrated at the inner face where the temperature is greatest. Figures 1 and 2, containing photographs of two roof brick, show the degree to which impregnation has taken place. The chemical composition of the solid matter contained in the furnace atmosphere, as shown by analyses of various silica brick taken from roofs, sidewalls, bulkheads, downtakes, and checkers as well as the deposited material in slag pockets and regenerators, is largely iron oxide and calcium oxide. The ratio of these two substances varies in different furnaces and undoubtedly at different times in the same furnace; however, evidence gathered thus far indicates that iron oxide predominates. The ratios of iron oxide to calcium oxide in samples of silica brick have ranged from 2:1 to 5:1 and in samples of checker deposit from 5:1 to 10:1; this, in spite of the fact that the refining slags contained iron oxide and lime in the ratio of about 1:3. This slagging action by basic oxides is very important and points out the fundamental fallacy of using silica ware above the slag line in either the acid or basic open-hearth furnace.

The method by which these basic oxides are taken up by the gas stream, their chemical composition, and physical state are not known definitely. Undoubtedly, most of the iron oxide is introduced by the burning of light weight steel scrap during melting and by the oxidation of molten iron dur-

[1] C. L. Kinney, Jr., and G. R. McDermott, "Thermal Efficiency and Heat Balance of an Open-Hearth Furnace," Yearbook, Am. Iron and Steel Inst. (1922).

ing the "boiling period" when the entire bath of metal and slag is being violently agitated. Thus, the hot oxidizing gases are intimately mixed with the metal and are afforded a fine opportunity to produce iron oxide and carry it away. Lime and other ingredients of the slag are also picked up by the furnace gases at this stage.

FIG. 1.—Cross-section of brick taken from roof of open hearth after 125 heats.

FIG. 2.—Side of brick taken from roof of open hearth after 30 heats.

Spalling and Breaking

New furnaces are brought up to operating temperature gradually and spalling is avoided as far as possible. However, brick used for patching hot furnaces are subjected to extremely rapid changes in temperature. Silica brick spall badly under such conditions. The use of hot silica brick for this work has proved advantageous in some cases. Chrome brick have given excellent service in patching hot furnaces. Silica brick in which the quartz has been converted to tridymite should be desirable for such use provided they could be produced cheaply enough. Silica brick in roofs are often cracked by excessive pressure at certain points caused by the brick having uneven surfaces. The lower portions of such brick drop out and the surrounding brick, with new sides freshly exposed, either spall or

are rapidly corroded, producing a large weak spot in the roof which must soon be repaired.

Back walls are injured when rammed by the charging machine. This danger may be averted, or, at least, the extent of injury may be minimized by building into the brick work heavy iron bars which run horizontally across the wall.

Regenerators and Slag Pockets

Regenerators fail largely as a result of the deposition of dust coming from the open hearth. This dust gradually chokes the system and also forms a glazed surface on the brick by slagging the exposed face. Both actions cause inefficiency and ultimately make a cleaning out or rebuilding necessary. The rate at which steel is produced by the open-hearth furnace decreases as the checker work becomes clogged. Hence, the regenerators are cleaned and rebuilt, when, in the judgment of the operator, further use of them becomes uneconomical. Thus it is that the life of checker chambers varies in different plants using similar practice, some operators preferring a long checker life at the expense of diminished output.

The checker deposit consists of particles of iron oxide, lime, etc., carried from the bath, and also, in some cases, carbon and ash from the fuel burned. The analysis of a typical deposit of unfused material found in the checkers of a furnace burning oil and melting all steel-scrap charges follows: SiO_2, 10.2; FeO, 66.3; CaO, 4.9; MgO, 0.9; carbon, 0.07%. Some slag adhering to the brick contained SiO_2, 40.5; FeO, 27.0; CaO, 3.4; MgO, 0.2; carbon, 0.11%. Tar when burned in the open hearth sometimes causes the deposition of carbon in the checkers, and powdered coal may cause both coal-ash and carbon to be carried into the regenerators. Quigley[1] gives the following to show the effect of various kinds of fuels on the life of the checkers:

Number of Heats Before Cleaning Checkers	
Natural or coke-oven gas	300–600
Coke-oven gas and tar	200–300
Oil or producer gas	200–300
Tar	175–250
Powdered coal	75–125

The usual size of the checker openings is of necessity a compromise between large and wide openings to prevent early clogging by dust, and small and narrow openings to get efficient transfer of heat. It is claimed that at one plant the deposition of dust is prevented to a large degree by maintaining a uniform rate of flow of gases through the checkers. This is

[1] F. B. Quigley, "Open-Hearth Furnace Regenerators," Am. Iron and Steel Inst., Oct. 25 (1923).

accomplished by making the checker openings larger at the top than at the bottom and gradually reducing their area in stages going toward the bottom. Other designs make possible the periodic blowing of the chambers with air to remove deposited material. At another plant the brick are specially shaped so that no corners will project to catch dust particles suspended in the gas stream.

Although much is to be gained in the better design of regenerators to prevent the deposition of solids, it seems more logical to remove these solids from the gas stream before it reaches the checkers. This is the purpose of the slag pockets but their performance is far from perfect. As the slag pocket becomes filled, the gases pass more directly to the regenerators and, as a result, less of the solid particles are removed from the gas stream before it enters the checkers. Methods for removing the slag periodically either by chilling and dropping out the granulated material or by keeping it molten and removing by tapping are helpful. The insertion of baffle walls causes a larger deposition of solids but the maintenance of these walls presents a difficult refractories problem itself.

Where sufficient room can be had, it may be advisable to construct a large chamber between the slag pockets and the checker work to permit a further deposition of entrained particles from the gases. Another possibility would be the electrical precipitation of the solid particles from the gases by some such method as is used in removing solids from lead and copper smelter gases; but on account of the high temperatures involved, present equipment and methods could not be used.

The highest temperature in the regenerators is at the top where the hot gases enter and is ordinarily between 2400 and 2600°F. Thus, the brick at the bottom are under the heaviest load and at a comparatively low temperature, whereas the brick at the top are at a high temperature and under the lowest load. Occasionally, checker brick are fused, but failure of regenerators due to this cause is not so important as that due to deposition of dust.

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FIRE-CLAY BRICK FOR THE OPEN HEARTH[1]

BY M. C. BOOZE

ABSTRACT

Fire-clay brick in the open hearth are normally subjected to medium temperatures and to the action of slag containing high percentages of iron and lime. Temperatures near the maximum of the open hearth itself may exist due to failure to reverse the draft and for that reason brick of high refractoriness are used. Resistance to spalling

[1] Presented at the Atlantic City Meeting, Feb., 1924 (Refractories Division).

action is not of primary importance because the temperature change is small. The indications obtained from a laboratory test were that brick having a high alumina content would resist the slag action better than ones higher in silica.

The use of fire-clay brick for open hearth furnaces is confined almost entirely to the regenerators. In this position they are subjected to the heat of the outgoing gases, to the slagging action of the dust carried by the waste gases and to temperature changes at frequent intervals.

Although the furnace itself may be operated at a temperature in the neighborhood of 3000°F, the waste gases entering the checker chambers are not in excess of 2600°F. This is due to the loss of heat to the walls of the flues leading to the checker chambers. The temperature, however, may approach the actual furnace temperature if for some reason the dampers are not reversed at the regular period. They are also dependent somewhat upon the construction and operation of the furnaces.

The following temperatures have been given for furnaces operated in various plants:

Plant	Temperature	Temperature drop during reversal
1	Air checkers 2600°F max. Gas checkers 2400°F max. Gases leaving checkers 1400°F max.	250°F–500°F
2	Air checkers 2350°F max. Gas checkers 2100°F max. Gases leaving checkers 1600°F	
3	2200°F max. Not stated whether in air or gas checkers.	200°F–300°F, where draft is reversed every 15 minutes.

It will be noted that in both cases where air and gas checker temperatures are given, the latter is the lower. This is partially due to the gases entering the flues leading to the gas checkers through a water cooled port. While the normal temperatures existing in either regenerator are not exceptionally high, the brick used must be of ample refractoriness to withstand the extreme temperatures which may prevail for short intervals due to some abnormal operating condition.

The temperature change taking place when the draft is reversed is rapid, but covers a narrow range and the minimum temperature is also high, so that the stresses tending to cause spalling are of little importance.

The height of the checker brick setting is rarely above 15 feet and since the checkers are set open in order to present a large heating surface, the load on the bottom brick would attain a maximum of not over six or seven pounds per square inch. The temperature at the bottom of the checkers, where the maximum load occurs, is comparatively low, so that little or no deformation or crushing would be expected even on brick having relatively low strength. The available data bear this out, it being stated that no failure from such cause has been observed.

The deposition of dust on the checkers eventually causes such clogging of the regenerator that the furnace must be shut down and the checkers cleaned. The number of heats between cleanings varies with different plants, but when producer gas is used it is considered that 300 heats is very satisfactory. When such cleanings are made, the top eight to twelve courses of brick are usually found to be so eroded and sintered together by slag that they cannot be salvaged. The lower courses, however, are less affected and may be used several times before they must be replaced. The explanation for this difference lies in the difference in temperature from the top to the bottom of the checkers, those at the top operating at 700–1000°F hotter than the lower ones. It is evident then that brick in the top rows of the checkers which did not slag readily would retard the clogging action and would increase the efficiency of the regenerator when measured over a long period. Silica and magnesite have been tried for this purpose, but neither was sufficiently successful to warrant continuance of the practice. One objection to silica brick is that a low percentage is salvable upon cleaning, due to breakage.

As has been stated, the temperatures in gas checkers are lower than those in the air checkers and for this reason if for no other the gas checkers are less slagged than the latter. There also is a carbon deposit made on the gas checkers which prevents to some extent the adherence of the slag. The volume of gases passing through the gas checkers is relatively smaller than through the air checkers and so less dust per unit of brick is carried in and deposited. Since the waste gases entering the gas checkers go through a port below the center of the passage to the air checkers, it is probable that the dust carried into the former would not have the same composition as that entering the latter. The following analyses bear this out:

	Slag from air checkers	Slag from gas checkers
Silica	16.69	24.53
Alumina	23.08	15.36
Iron Oxide	45.46	43.92
Lime	11.14	9.77
Magnesia	3.55	1.83
K_2O and Na_2O	1.57	3.90
Fusion point	Cone 8	Cone 6

A third analysis for such slag which has been obtained from a steel plant laboratory is as follows:

Silica	45.75	Lime	4.59
Alumina	4.84	Magnesia	3.44
Iron oxide	28.17	Carbon	0.08
Manganese dioxide	0.67		

It was not stated whether this came from the air or gas regenerator.

It has been the general practice to use first quality fire-clay brick in both regenerators. The experience of one steel plant has been that machine made brick give better service than hand-made, it being these peoples' belief that the resistance to slag action was greater, that the thermal efficiency was greater, and that they laid up better due to greater uniformity.

Using the two slags whose analyses were given previously, tests of four kinds of brick varying in silica content were made by determining the fusion point of cones made from mixtures containing 75% brick and 25% slag. The results obtained were as follows, using slag from gas checkers:

Brick sample no.	Silica	Alumina	Fusion point of slag-brick mixture
1	39.7	54.1	15–16
2	72.0	25.0	8
3	94.0	2.0	20
4	49.7	44.7	14–15

Fusion point of slag alone—Cone 5

Using slag from air checkers:

Brick sample no.	Silica	Alumina	Fusion point of slag-brick mixture
1	39.7	54.1	26–27
2	72.0	25.0	13
3	94.0	2.0	15
4	49.7	44.7	20–26

These results indicate but little advantage in the use of a highly aluminous material over good fire brick. It is probable that brick with a higher alumina content than those given as No. 1 would show less reduction in refractoriness, but the cost would be high for material of this quality.

The data presented here refer entirely to furnaces using producer gas as fuel and will not necessarily hold for other methods of heating. One writer states that the checkers must be cleaned every 75 to 125 heats when powdered coal is used, due to the coal ash being carried in, as compared with cleaning every 200 to 300 heats when oil or producer gas is used. In addition to the differences in the deposits, a variation in checker temperature would be expected with other kinds of fuel. The use of producer gas is common, but is being displaced to some extent by coke oven gas.

It has been indicated that fire-clay brick which will withstand a high temperature and which will not be rapidly eroded by slag will give good service in these regenerators. It has not been well established whether a dense or open brick has the higher thermal efficiency for this purpose and the latter problem should receive some attention.

Liberal use has been made of articles by Quigley "Open Hearth Furnace Regenerators,"[1] Kinney and McDermott, "Thermal Efficiency of

[1] American Iron and Steel Institute Meeting, October, 1923.

the Open Hearth Furnace,"[1] and of data obtained from private correspondence with men acquainted with open hearth furnace operation. The only original data presented are those on analyses of slags taken from air and gas regenerators and on the results of fusion tests made with these slags.

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CHROME REFRACTORIES FOR THE OPEN HEARTH[2]

BY RAYMOND E. GRIFFITH

ABSTRACT

This is not a technical paper but a compilation of notes on chrome ore, and the various forms in which it is used in open hearth furnaces, with a discussion of recent improvements in chrome brick that have permitted their broader use. Also some performance data secured through the courtesy of many companies and individuals operating open hearth furnaces.

Introduction

There is probably no other refractory used in the basic open hearth furnace that is of greater value, from a standpoint of utility or performance, than chrome ore; nor is there any other refractory material, the successful use of which, in many forms, is so rapidly increasing, and in such a variety of applications.

Chemists, metallurgists, engineers, in fact most everyone connected with the steel industry can claim a pretty thorough knowledge of the value and functions of chromium in metallurgy but it has been only in comparatively recent years that any serious study has been given the refractory qualities of chrome ore that would tend to broaden its application or encourage its more intelligent selection for refractory purposes. Nor has there, until recently, been much evidence of a desire on the part of the consumer to differentiate between good and bad chrome brick or ore. So long as the chromic oxide content was above a certain minimum, and sometimes maximum silica specified, the other elements, the form in which they were present, or their relation to spalling, refractoriness and the many other properties that affect performance, were apparently of no consequence to the consumer.

It is the writer's purpose to avoid, as much as possible, the technical side of the subject except to present results of some fusion and slag tests on chrome ores and chrome cements; also to mention certain observations on chrome brick reported by some investigators, which might be misinterpreted by consumers, or at least might be applied generally to all

[1] Iron and Steel Institute, 1923.

[2] Presented at the Atlantic City Meeting, Feb., 1924 (Refractories Division).

chrome refractories while the investigation may have been, as is usually the case, confined to one grade of chrome and presented without any qualifying statements as to its physical nature, frequently not mentioning its chemical composition.

Some chrome ores of very good chemical analysis are practically useless for brick making on account of their physical condition, being friable and of a sandy nature.

The hard, dense ores from Rhodesia, South Africa, that break up into sharp, irregular-shaped grains when ground, undoubtedly make better chrome brick than any of the more friable ores.

About 1920 ceramic engineers of E. J. Lavino and Company, and the writer, began a study of the chemical and physical characteristics of chrome ores from all known deposits of commercial importance; the primary object of this effort was to determine the various forms in which the different elements occur in the crude ore, and to observe their effect on the bond, physical strength, resistance to chemical reactions and spalling tendencies of chrome brick. Very interesting facts have resulted; certain phenomena cleared up and manufacturing difficulties eliminated; thus, through a better understanding and control of chemical and physical changes that take place during the burning process, chrome brick are now being produced possessing chemical and physical excellence not previously accredited to this type of refractory.

Refractoriness of Chrome-slag Mixtures[1]

(Extracts from tests made for E. J. Lavino and Company, by R. M. Howe, formerly Senior Fellow, Refractories Manufacturers Association Industrial Fellowship, Mellon Institute of Industrial Research, Pittsburgh, Pa., and Mark Sheppard, formerly Ceramic Engineer, E. J. Lavino and Company.)

The following results were obtained by fusion tests to determine the resistance of chrome ore and chrome cements to slags as well as high temperatures.

Test A.—Actual fusion point of "Imperial" chrome ore without addition of slag was not definitely determined, but a fusion point above cone 38 was demonstrated.

Test B.—Straight "Imperial" chrome ore and four grades of specially prepared chrome cement each mixed with 10% acid open hearth slag were rigid at cone 34.

Test C.—Four grades of special cement each mixed with 20% acid open hearth slag were just beginning to react at cone 34. Straight "Imperial" ore and 20% acid slag was not affected, at cone 34.

Test D.—The same materials, each mixed with 20% basic open hearth slag all remained firm at cone 34.

[1] These additions reduced chromic oxide content in mix to about 40%.

Effect of Impurities in Chrome Ore[1]

Following results obtained by adding to the natural "Imperial" ore 20% each of silica, iron, alumina and magnesia.

Test no.	Approximate total impurity in mix	Fusion point
1 Silica	25.84%	Cone 27½
2 Iron Oxide	30.80%	Cone 33
3 Alumina	31.77%	Vitrified at Cone 33
4 Magnesia	31.36%	Unaffected at cone 33

It seems obvious, from this test that the elements which reduce the refractoriness of chrome ore are, in the order of their importance as fluxes, silica, iron oxide, alumina and magnesia. The last, however, having only slight effect on the fusion point of chrome ore. The practice is fairly common to mix dead burned magnesite with chrome ore, sometimes in equal proportions, for patching bottoms and many other parts of basic open hearth furnaces.

Properties of Chrome Brick

The general properties of chrome brick as reported by various observers, compiled by McDowell and Robertson and together with other valuable data, are most ably presented under the subject "Chrome Refractories."[2] Engineers, chemists, metallurgists and others interested in the subject will find this valuable contribution interesting and profitable reading. However, certain statements regarding spalling tendencies and physical weakness under load at high temperatures, to which many consumers are inclined to attach undue importance, might be modified to conform more closely with recent performance in the laboratory and in actual practice, of brick made in commercial quantities from ore analyzing 47 to 51% Cr_2O_3, ore selected with regard to its physical as well as chemical adaptability.

Chemical Analyses

	Sample No. 1 Per cent	Sample No. 2 Per cent	Average Per cent
Cr_2O_3	50.00	49.72	49.86
SiO_2	7.42	4.78	6.10
Fe_2O_3	17.54	17.22	17.38
Al_2O_3	11.50	14.01	12.76
MgO	12.66	12.31	12.49
CaO	0.00	0.00	0.00

Each of these samples was composed of spalls from 50 brick. The two analyses represent the product of four different kilns, samples 1 and 2

[1] These additions reduced chromic oxide content in mix to about 40%.

[2] *Jour. Amer. Ceram. Soc.*, **5** [12], 865–87 (1922).

made from slightly different ores, chemically, but possessing about the same physical characteristics.

Crushing Strength

Many times in the last two years these brick have been subjected to the standard load test and in every instance except some experimental mixes, the point of failure was between 1430° and 1470°C. While the load test as now employed is not, in the writer's opinion, at all representative of furnace conditions, but suitable only for comparisons, many furnace builders and operators are influenced in their selection of refractories by results obtained in this as well as other irrelevant tests; therefore, it may serve some good purpose to compare this behavior of chrome brick with some of the other commonly known refractories.

Fire-clay brick and bauxite brick, in the standard load test soften at about 1300°C. Magnesia brick frequently shears at 1400° to 1500°C (sometimes as high as 1550°C). Silica brick shears at about 1600° to 1650°C. It is obvious that, of the small group of refractories suitable for metallurgical furnaces, chrome, so far as crushing strength is concerned, is better than fire clay or bauxite and about equal to magnesia brick.

Sensitiveness to Temperature Changes

The best evidence that considerable progress has been made toward reducing if not eliminating the spalling tendencies of chrome brick is the fact that many plants now use them for all hot repairs to front walls, back walls and other parts of open hearth furnaces; they stand temperature changes much better than magnesia or silica brick.

Chrome Brick in the Open Hearth

It is doubtful if, prior to 1916, it would have been possible to find a basic open hearth furnace in America with a complete chrome brick bottom. During the war there were a few cases where chrome were used in the place of magnesia brick, but because the latter were not immediately available and the demand for steel was so great that such apparent disregard for precedent was entirely permissible; however, since the latter part of 1920 improvements in the quality, and favorable market conditions have influenced consumers to take a more serious interest in chrome brick. In the last two years chrome brick have been used for the entire bottom and at the base of front and back walls, up to a safe distance above the slag line, in at least eighteen basic open hearths. Sixteen open hearth plants, with a total of 232 furnaces have adopted chrome as the most desirable brick for bottoms and many other parts of basic furnaces, replacing magnesia and in some places silica brick.

Specific Applications with Performance Data

While much of the following is apart from the main subject it will undoubtedly prove interesting to operating men. The writer made a personal investigation in a number of plants to secure first-hand information, some of which is of a nature that might be considered confidential therefore the source is designated by number only.

PLANT NO. 1

All open hearth furnaces basic (75-ton capacity).

Fuel.—Producer gas (average about 580 pounds coal per ton of steel).

Bottoms.—Last two rebuilt with chrome brick (two flat courses and one rowlock). All new bottoms are made with dead burned magnesite burned in on top of chrome brick. For all ordinary patching dolomite, calcined in their own cupolas is used. Use very small amount of grain magnesite for bottom repairs, about one half pound per ton of steel. Average consumption of dolomite charging 50% hot metal, is 60 to 70 pounds per ton. Charging 65% hot metal, dolomite consumption is usually 80 to 85 pounds per ton of steel.

Walls.—(Front and back.) Chrome brick at base; silica brick above slag line. Siliceous slag from silica walls seems to build up on chrome brick while it will cut out magnesia brick.

End blocks and monkey walls.—Built of selected lumps of "Imperial" chrome ore.

Ports.—Water cooled, paved with silica brick, faced or protected with ground chrome ore.

Bulkheads.—{Gas—silica brick / Air—silica brick} Run 35 to 40 heats without patching.

Roof.—12-inch silica, average life, new roof is about 190 heats before patching; with care in heating up and proper repairs, total life of center section (from knuckle to knuckle) is 250 to 300 heats.

Remarks.—Operating men in this plant expressed the opinion that crude ore, in the form of hard, dense lumps is the most economical and serviceable refractory available for use in monkey walls and end blocks. The service life is greater than other materials, also much higher salvage.

After more than two years experience, replacing magnesia brick with chrome they have found no apparent difference in the bottom but where they are exposed to temperature changes or come in contact with the drip from the silica walls, the evidence is strongly in favor of chrome brick.

PLANT NO. 2

Furnaces all basic (80 tons capacity).

Fuel.—Producer gas. Best furnace on producer gas averaged for the month, 480 pounds coal per ton of steel. Total production for the month 6000 tons steel.

This record made by an eighty ton basic furnace of special design which permits better direction of the flame, also more intimate mixture of gas and air. An incident in connection with this new furnace is a reduction in the steam pressure at the producer from 35 to 40 pounds down to 12 to 15 pounds. Regular 80-ton furnace, same plant, produced 5000 tons steel. Coal consumption 680 pounds per ton.

Bottoms.—One complete chrome brick bottom.

Walls.—(Front and back) now using chrome brick at the base of front and back walls in all furnaces. Silica brick above slag zone.

End blocks.—Lump chrome ore.

Monkey walls.—Patented magnesite brick in some furnaces, lump chrome ore in others. Service life is about the same, but first cost of lump ore is a great deal less with higher salvage value.

Ports.—Water cooled; use ground chrome ore for protecting floor of ports. In special furnaces previously mentioned the port arches form mixing chambers for gas and air. Extremely high temperatures are easily attained at this point. Selected lumps of chrome ore, bonded with "Kromepatch" are used for constructing these arches; all other refractories they have tried so far have failed to give satisfactory service. The contour of the arch or mixing chamber is maintained by a nest of water cooled pipes imbedded in the refractory and which also help to support it.

Bulkheads.—(Gas and air.) Silica brick, usual life 40 to 45 heats.

Roofs.—12-inch silica. Average life 200 to 250 heats.

Remarks.—Men in this plant expressed a preference for chrome brick. Said they would not hesitate to use chrome any place in an open hearth furnace where magnesia brick can be used.

PLANT NO. 3

All basic open hearth furnaces, 100 tons rating. Melting 130 tons per heat.

Fuel.—Producer gas. Average 508 lbs. coal per ton of steel, 30% hot metal.

Bottoms.—Has not been necessary to rebuild any bottoms since the plant began operations. Have adopted chrome brick for all future bottom repairs and construction.

Walls.—(Front and back) chrome brick at base; silica above slag line.

End blocks.—Lump chrome ore.

Ports.—Water cooled; paved with silica brick faced or protected with ground chrome ore.

Bulkheads.—Silica brick; frequently necessary to replace after 10 to 15 heats.

Roof.—12-inch silica, average life 250 heats.

Remarks.—Men consider chrome brick, equal to magnesite in every respect.

PLANT NO. 4

Basic open hearth furnaces, rated at 60 tons, melting about 83 tons per heat.

Fuel.—Producer gas, average coal consumption 600 lbs. per ton of steel, charging 50 to 55% hot metal. Operate new or rebuilt furnaces 100 to 150 heats on producer gas, then change to coke oven gas and tar.

Bottoms.—Most of the furnaces have the original bottoms still in service; however, contemplate using chrome brick for all new or rebuilt bottoms.

Walls.—(Front and back) have been experimenting for some time with lump chrome ore back walls; have had as high as 9 chrome ore back walls in operation at one time. These walls are usually 22 to 26 inches at the bottom tapering back to 13 to 18 inches thick at the top. It is now the practice to use four courses of chrome brick at the top of the wall.

To reinforce the back wall $1^3/_4$" or 2-inch square bars, about 12 inches apart run the full length of the wall imbedded in the outside face.

Complete front wall recently installed, using selected chrome ore lumps. At time of inspection this front wall had run 103 heats; in excellent condition except two red spots near the skew-back.

One important advantage, in addition to the much greater life of these chrome ore walls compared with silica, is the fact that, contrary to the silica wall, the chrome wall wears away at the top instead of the bottom. With minor repairs along the top of the wall this type of construction lasts the full run of the furnace, frequently running 150 heats without any repairs.

End blocks.—Built of selected lumps of chrome ore. Usual life about 700 heats frequently lasting much longer.

Remarks.—Although the use of lump chrome ore (front and back) walls in this plant might still be considered in the experimental stage the results obtained have been encouraging and with further refinement in construction details will no doubt be adopted as standard practice and prove very economical.

PLANT NO. 5

Basic open hearth furnaces, rated at 100 tons, melting 120 tons.

Fuel.—Oil.

Bottoms.—Use chrome brick for all repairs and rebuilding.

Walls.—(Front and back) chrome brick all the way up to within a few courses of the skew-back, topped off with silica brick.

Furnace A—Chrome brick in back and front walls, air port bulkheads and end blocks. Furnace recently repaired using about 9000 chrome brick after run of 271 heats.

Furnace B—Recently repaired using 9000 chrome brick, previous run 280 heats.

Furnace C—After 90 days run, over 200 heats, this furnace was in good condition; front and back wall appeared to be good for another 100 heats.

Furnace D—Given a general overhaul and put in service October 15th; on January 30th still in service after 236 heats. Do not expect to take this furnace off for another month which will give it a total run approximating 300 heats.

Furnace E—Taken off for repairs after 295 heats.

Remarks.—Chrome brick were used in the back wall in each furnace mentioned and chrome brick front walls in some of them.

In all these cases chrome brick bulkheads, and uptakes faced with chrome brick, have lasted the full run of the furnace.

Silica brick in these bulkheads would give in this plant about 20 days' service, about 45 to 50 heats. In back walls the life of silica brick is about 45 to 60 heats.

PLANT NO. 6

Basic open hearth furnaces, some 100 tons, others 70 tons capacity.

Fuel.—Producer gas, also one furnace on oil. Coal consumption, producer gas furnaces 675 lbs. per ton of steel; charging all cold metal. Oil-fired furnace, consumption fuel 44 to 45 gallons oil per ton of steel.

This plant runs extremely hot heats, tapping at approximately 2950°F, compared with 2700 to 2800 in ordinary practice. On account of charging cold metal and high heat required, it is considered good practice to get a 100-ton melt in 12 hours.

Bottoms.—Have not, so far, used chrome brick in the main bottom but they are considered suitable for this work and will no doubt be used for future rebuilding.

Walls.—(Front and back) chrome brick used at base of wall running up to about 5 courses above door sill, silica above this point. Silica walls usually repaired after 20 to 30 heats.

End blocks.—Faced with chrome brick.

Ports.—Some water cooled, others built of silica brick protected with ground chrome ore or "Kromepatch." Prefer the latter as it gives 2 to 3 times the service of regular ground chrome ore. This longer service is due to the fact that straight ground chrome ore does not develop sufficient bond to hold it in place at the lower temperatures, therefore most of it falls off long before the bonding temperature is reached.

Bulkheads.—(Gas) patented magnesite brick. Wall 13½ inches thick. Experimenting with chrome brick. (Air) silica brick.

Roof.—12-inch silica; usually runs about 125 heats, then after general repairs gives about 125 to 130 heats more; some roofs have given as high as 300 heats which is considered a very good run in this plant.

Remarks.—Very well pleased with service rendered by chrome brick in all parts of the furnace where magnesia brick were formally used. Also use about 18 inches of chrome brick at the base of walls in soaking pits.

PLANT NO. 7

Basic open hearth furnaces, running 63 tons per heat; average heat 9 hours.

Fuel.—Producer gas; coal consumption 580 lbs. per ton of steel, 45% hot metal. With a new furnace, clean checkers, properly shaped ports, tight valves, and other factors effecting economy favorably they have produced steel for a short period with a coal consumption of 450 lbs. per ton.

Bottoms.—One complete bottom chrome brick; and they have also been adopted for all future bottom repairs and rebuilding.

Walls.—(Front and back) chrome brick at the base, silica above slag zone.

End blocks and monkey walls.—Faced with chrome brick.

Ports.—Water cooled; gas uptakes faced with chrome brick above hearth level.

Bulkheads.—Silica, 20 to 25 heats average life.

Roof.—12-inch silica, 250 to 300 heats.

Remarks.—Also use chrome brick in soaking pits, 7 courses at the base of the walls. Very well satisfied with service obtained from chrome brick they prefer chrome brick in the soaking pits and consider them fully equal to magnesia brick in the open hearth.

Conclusions

Many failures of the high grade ground chrome ores in the open hearth are, contrary to the general belief, due to their high refractoriness and difficulty of bonding at the lower temperatures.

Synthetic chrome cements, intelligently prepared, composed of high grade chrome ore, finely ground and intimately mixed with slightly less refractory but very plastic materials, so proportioned as to give the desired plasticity, strength of bond and adhesiveness without an appreciable sacrifice of refractoriness give much longer service (often lasting three times as long) hence, greater economy, than any straight ground chrome ore for patching and protecting front walls, back walls, port arches, inclines, end blocks, uptakes, door jambs, etc. In most cases where straight ground ore is used more than half the ore applied to a furnace wall falls off long before it gets hot enough to bond together or stick to the brick work.

Walls, end blocks and other structures built of crude chrome ore lumps would be more rigid and monolithic, with greater resistance to impact, corrosion, abrasion and other destructive forces if the uneven blocks were laid in a synthetic chrome cement composed of materials that would give maximum binding strength with the least possible decrease in refractoriness.

Chrome ore has remarkable resistance to the fluxing action of acid or

basic slags and all chemical reactions encountered in the open hearth furnace. Its neutral characteristics and high refractoriness give it a broader field of usefulness than most other refractories. Synthetic cements made of high grade chrome ore are now used for laying magnesia, chrome, silica, fire clay and other types of brick.

High-grade chrome brick have proven fully equal to magnesia brick in basic open hearth bottoms and superior to magnesia or silica brick in bulkheads, gas and air uptakes, back walls, front walls and other places where conditions are most severe. Even a properly designed chrome brick roof is within the realm of possibilities which would permit longer runs between rebuilds, greater output per furnace and consequently lower cost per unit of output.

The remarkable increase in the use of chrome refractories made possible by improvements which, compared with probable future developments may seem insignificant, causes the writer to suggest that research and a study of service conditions, looking toward the improvement and more intelligent use of chrome, magnesite, silica, fire clay and other well known refractories is likely to give consumers more immediate and economical relief from their various refractory troubles than the development of super-refractories at costs which seem prohibitive and so far have discouraged their use in the open hearth and most other ordinary types of furnaces.

PHILADELPHIA, PA.

ROOF BRICK FOR THE OPEN HEARTH[1]

BY H. C. HARRISON[2]

ABSTRACT

The conditions under which a roof brick has to stand are considered and possible means of improving refractories in common use suggested. A brief mention is made of the possibility of utilizing other available refractories.

Introduction

Open hearth operators have about reached the limit of economy in steel making until they can employ higher hearth temperatures. In order to permit of this improved operating condition, the steel men must either be furnished with better refractories or else the refractory materials now in use must be utilized to better advantage.

In order to open the question of roof brick, let us first consider the conditions under which a roof brick has to stand and, second, suggest methods for realizing a greater service from the refractories now in common use. The third point will have to do with what has been done in the way of

[1] Published by permission of the Director, U. S. Bureau of Mines. Presented at the Atlantic City Meeting, Feb., 1924 (Refractories Division).

[2] Assistant Metallurgical Engineer, Ceramic Station, U. S. Bur. of Mines, Columbus, Ohio.

improving the refractories in common use; and lastly, the possibility of utilizing other available refractories.

Even with the great variation in design, fuel, and operating conditions in the open hearth furnace, it still remains that the life of the furnace is limited by the life of the refractories used in the various parts. In all cases, the refractory in the roof of the open hearth if not the limiting factor, is one to be seriously considered.

In basic open hearth practice the life of the roof, with minor repairs, ranges from 80 to 350 heats, as found by a survey of furnace operating conditions. A high average life of the roof in basic practice is about 250 heats, while in acid practice on the average it is 700 to 800 heats. The ultimate failure of the roof is caused by the drip fluxing away the bricks until the roof will no longer support itself. The point of greatest attack in many cases is reported to be near the skew-back of the back wall opposite the middle door. The draft from the door tends to roll the flame up to the roof causing a local heating.

Operating Conditions

The operating conditions under which the roof brick are required to stand are not known with certainty. The temperature of the hot face is not definitely known nor are the gases near the roof known to be always oxidizing, although they are assumed to be such. The amount of suspended material in the gases in contact with the roof has not been determined. The character of the slag material coming in contact with the roof has never been shown to be the same as that in the bath, although this has been assumed in slagging tests.

Temperature near Roof The temperature to which the interior of an open hearth furnace near the roof is subjected in present practice, is probably between 3000 and 3200°F. The practice of the operator in general is to drive the furnace until the roof brick begin to drop or at least show a very decided tendency to do so; that is, the refractory in the roof is the indicator for the maximum working temperatures.

Load Conditions The load carrying characteristics of a roof brick at temperatures very close to its softening point is an all important consideration in furnace design where the roof is self-supporting, as in general practice. Even though the material had all the other characteristics of an ideal refractory, it would be of no use if it lacked ample strength to support the roof load at service temperatures.

Slag Conditions Slag action is an important factor in the ultimate failure of open-hearth roof-brick. The brick in service must resist the action of a basic fog, possibly carrying some very fine slag spray, in an atmosphere which is probably oxidizing at a tempera-

ture very near to their softening point. The basic fog referred to is composed of vaporized metallic oxides from the hot bath as well as dust from the charging. In basic practice the oxides of iron and lime predominate and in acid practice, the oxides of iron. The chemical nature of any fine slag spray that might be carried to the roof is, of course, dependent upon the process being used. An analysis of the drip from a basic open hearth furnace using a silica roof showed it to consist principally of iron oxides together with considerable amounts of silica and lime. The above consideration seems to indicate that a neutral or slightly basic roof would be the most desirable in both acid and basic open hearth practice since in both, the roof is subjected to a basically charged atmosphere.

The greater length of life of a silica roof in acid practice, it being practically three times the life of a silica roof in basic practice, is due to the somewhat lower temperature possible in the acid process since no refining of the steel is accomplished.

Abrasion Conditions Abrasion is the least important of the factors leading to the ultimate failure of an open hearth roof. The requirements of the steel making process are such that the flame must impinge upon the bath. Furnaces in general are constructed so that the air port is above the gas port thus tending to cause a blanket of air next to the roof. The only time the flame plays along the roof is at times of minimum kinetic energy so that only the smaller suspended particles can reach the roof. Since these small particles must be in a very plastic state at the flame temperature, their abrasive action will be very small and at the same time there will be a tendency to cling to the roof, so that slag action and increased temperature due to the flame contact must be far more important than any abrasion that might take place.

During a survey of furnace conditions, some operators were found to be of the opinion that the roof was exposed to the most severe conditions when the bath was quiet and the surface inactive. The roof was assumed to be thus overheated by the smooth glassy surface of the slag acting to reflect the heat up to the roof. Another operator found the most severe conditions encountered when the bath was very active, probably due to the flame thus being deflected to the roof. In this case slag action might be a serious factor due to an increased amount of spray being carried to the roof. The later operator found the composition of the charge seemed to have a definite effect on the life of the refractories.

Taking all factors into account, the ideal roof brick must have exact size and shape. The chemical nature of the material should be such that it will not flux readily with the slag with which the surface is covered—as above shown this means that it should be neutral or basic in nature. The brick must stand under working conditions with the hot face exposed to a temperature very close to its softening point. The porosity of the

brick must be as low as is compatible with a low spalling value so that it will not absorb fluxes, which will lower its softening point. Finally the higher the softening point of the brick, the more nearly ideal it will be.

Thermal Conductivity Several writers have pointed out that the thermal conductivity of the roof brick is an important factor in determining the maximum working temperature they will withstand, since it is this property which determines the rate at which heat is removed from the hot surface of the brick. Hull[1] has shown in this connection that the need of more reliable and usable data on thermal conductivity of refractories must be emphasized, especially the need of data on thermal conductivity of commercial refractories in fabricated combinations. A point that detracts from the utility of available data on thermal conductivity of refractories is that the determinations are made on small or special shapes of questionable similarity to commercial brick while the values are intended for use on bricks in fabricated combinations. Beecher[2] has recently published values for the conductivity of silica brick at a fraction of previous values and below that of fire clay, while previous work has placed the silica in some instances above the fire clay, also, it is a generally accepted fact by furnace men that silica will transfer more heat than fire clay.

The most desirable combinations of refractoriness and thermal conductivity cannot be stated until more is known of the thermal conductivity of furnace settings. One operator stated the very decided opinion that he could raise the over-all efficiency of his furnace if given a roof brick of greater refractoriness, due to the possible utilization of a higher flame temperature, even though the new refractory had a decidedly greater thermal conductivity than silica brick.

Utilization of Refractories

Suspended Roof The importance of the load carrying characteristics of the brick at high temperature could be reduced by designing the furnace with a suspended roof. Such a roof is being tested in at least one installation at the present time. The advantages of the suspended type of roof are obvious, in that the load carrying requirements of the brick are reduced to their own weight suspended from the cool side and the decided advantage of being able to replace sections of the roof which receive the greatest wear, thereby obtaining a maximum service from other parts of the roof. Another feature of the suspended roof is the possibility of suspending the bricks from a water cooled support thus increasing the life of the roof. It is true that in general, water cooling is

[1] Walter A. Hull, "Refractories in the Steel Plant," Year Book of the Amer. Iron and Steel Institute, p. 470 (1921).

[2] "Studies on Thermal Conductivities of Some Refractory Materials," *Jour. Amer. Ceram. Soc.*, **7** [1], 19 (1924).

undesirable around a furnace but cooling of the roof would be far less objectionable from an operating view-point than cooling the gas ports and the gain would very probably off-set the disadvantages. The cooling should only be sufficient to make the refractories stand up under the increased temperatures. Any cooling above this amount only increases the loss. In a number of cases where cooling is practiced, needless losses are incurred through excessive cooling.

Silica Brick as Roof Refractory

At the present time practically all open hearth furnace roofs are built of silica brick. The abundance and cheapness of siliceous material and its method of manufacture and its desirable properties make it an economical material. It, at the same time, has the disadvantage that it will not permit of a more advanced hearth temperature. Several other materials have been tried as roof brick but have not been able to compete with silica.

The properties of silica brick are a fairly high refractoriness; strength and resistance to abrasion while hot; high thermal expansion; and sensitiveness to rapid temperature changes below a dull red heat. These brick are especially adapted to roof construction because of their lightness and rigidity under load at high temperatures. Together with their desirable properties, silica brick have the undesirable properties of tending to spall and of being decidedly acid in character although they must serve in a basically charged atmosphere at high temperatures.

The Mineral Form of SiO_2 in Brick Is Important

Based on the exhaustive researches of Fenner[1] much technical information on the firing of silica refractories has been worked out. Silica may exist in brick in three mineral forms, namely—quartz, tridymite and cristobalite. In brick intended for open hearth roof construction, tridymite is the most desirable form. In commercial brick, about 80% of the quartz is inverted but only a few per cent of this is present as tridymite, the large majority is in the form of cristobalite. Brick which have been in service through the life of a roof, upon examination show that back of the fused surface practically all the silica is in the form of tridymite.

J. S. McDowell[2] has stated the desirable properties of tridymite as;

1. "Tridymite has the least thermal or temporary expansion of the three silica minerals."

2. "Tridymite has the greatest specific volume of the three minerals and cannot show any permanent expansion after repeated burning below its melting point."

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[1] C. N. Fenner, "Stability Relations of the Silica Minerals," *Amer. Jour. of Science*, **36**, 383 (1913).

[2] J. Spotts McDowell, "A Study of the Silica Refractories," *Trans. Amer. Inst. Mining Engr.*, **57**, 3 (1917).

3. "A tridymite brick could probably be subjected to fairly rapid changes of temperature with little danger of cracking."

How to Convert SiO_2 to Tridymite

As indicated by McDowell's work, in the present method of manufacturing silica brick the time element appears to be the most important factor in the formation of tridymite. In the firing of silica refractories the maximum temperature is maintained about 40 hours in usual practice If the maximum temperature, providing it is under 2678°F were maintained for $2^1/_2$ weeks, a brick consisting almost wholly of tridymite could probably be formed. The impracticability of producing a tridymite brick by this method is obvious.

C. L. Kinney[1] built the regenerators of an open hearth of silica brick which were removed after one campaign. It was found that the brick so treated upon being built into the back wall of the furnace, gave twice the life of ordinary commercial brick. This lengthened life was probably caused by the better development of tridymite during the extended firing in the regenerators.

Another possibility of producing a tridymite brick lies in using another flux either in addition to or in place of the lime now used. This flux must have a more active catalytic effect upon the inversion to tridymite than lime and at the same time must not lower the softening point of the brick to any appreciable extent.

Rebuffat,[2] upon investigating the properties of a quartzite that showed a high rate of inversion to the lower density minerals, found a small per cent of phosphorous present. He then added a small per cent of this element to a quartzite which was free of this flux. The presence of the phosphorous considerably increased the rate of inversion of the quartzite upon heating.

In nature the most active mineralizers are the hydroxyl group, boron, and fluorine. The temperatures at which silica brick are fired exclude the consideration of the hydroxyl group. At the present time, investigations are being made into the possibility of producing a commercial tridymite brick by the use of one or a combination of the above catalyzers.

The possibility of a tridymite brick suggests the possibility of a silica brick of greater density due to the lower spalling tendencies of tridymite. A brick of lower absorption is very desirable. The open hearth operator has found that he can obtain the greatest service from his roof brick by glazing the surface. His practice is to heat the new roof at the first melt so that tiny droplets form on the surface. If he is unfortunate and more than glazes the surface at any point, this point will be more easily fused

[1] C. L. Kinney, Jr., Discussion of "Refractories in the Steel Plant," Yearbook of Amer. Iron & Steel Inst., p. 511 (1921).

[2] O. Rebuffat, "Dinas Bricks of Constant Volume—Preliminary Note," *Trans. Ceram. Soc.*, **21,** 66 (1921–22).

than any other during the following melts. This effect is probably caused by an absorption of impurities by the porous brick which effect could be reduced by producing a denser brick.

Other Means of Improving Silica Brick

It[1] has been suggested that improvement may be expected from a more careful preparation of the raw material—more especially in regard to sizing and mixing. It also seems that a study of machine molding under increased pressures might be worth while. As these factors would have some influence upon the physical strength of the ware as well as upon the rate of inversion, improvements could possibly be effected. Whether the added cost would be justifiable would depend upon the product.

In all that has been said, it will be noted that no suggestion has been made as to how the refractory value of silica brick can be raised. The amount of lime necessary to give the ware the necessary dry bond has been reduced to the minimum. In most cases very pure raw materials are used, so little improvement is possible in the way of raising the actual softening point of the ware. This feature is an inherent limitation in silica ware and if greater refractoriness is important, other materials must be considered.

Other Roof Materials

Experimental open hearth roofs of carborundum, bauxite, and chromite have been reported. Sillimanite and spinel are being experimented with at the present time in back walls with the idea in view of adopting them to roof service.

So far, none of these materials have proven as satisfactory as silica in spite of the fact that they are, without exception, more refractory and less acid in character than silica. The causes of failure of the three full roofs above mentioned are reported to have been mechanical rather than service failures.

The case of the carborundum roof installation is interesting in that it shows a possible treatment of a material combining high thermal conductivity and high refractoriness to prevent excessive heat losses. In this case the carborundum was built in as an ordinary roof, then an insulating crown of fire brick was built above the carborundum with a 2-inch air space between the two crowns.

If the suspension principle of roof construction ever becomes popular, it is likely that some changes will be introduced in roof materials as several of the above mentioned materials have more to gain by suspension than has silica. Magnesite and chrome especially come in this class since they

[1] E. E. Ayars, "How Good Silica Brick Are Made," *Brick and Clay Record*, Oct. 30, 628, and Nov. 13, 698 (1923).

have the advantage of high fusion points but will not sustain load at high temperatures. Along this same line it will be well to mention that one concern is at present figuring on building an all chrome furnace. It is very likely however that silica, due to its low selling price, will always be in demand except where exceptionally high hearth temperatures are desired.

COLUMBUS, OHIO

SOME CONSIDERATIONS NECESSARY IN SELECTION OF REFRACTORIES FOR THE OPEN HEARTH[1]

A SYMPOSIUM CONDUCTED BY D. A. LYON

MR. CORNELL: Mr. Crosby stated the life of an electric furnace in pounds. I would like to know what they consider satisfactory for their furnaces on heats, not pounds.

DR. MACK: 2,000,000 pounds of yellow metal or one and one-half million pounds of red metal was given as the life per lining. This is for the moving, indirect-arc type furnace. Converted, this would be about 1500 heats. Some linings will fail earlier than that, but 2000 heat lives are not unusual. Around 1500 heats mark the point, with present refractories, where replacement of the lining becomes advisable.

MR. CORNELL: Every steel plant engineer recognizes that there are first, second and third quality fire-clay brick. This is also recognized by the brick manufacturers. Why can we instead of having everything presented on first quality, not have something on second and third quality definitely stated?

MR. ROSS: No man likes to say first, second and third quality for his brick. The A. S. T. M. classifies one brick as suitable for a particular service and another brick suitable for some other service, etc. In a few years this should eliminate that trouble altogether.

MR. AYARS: In connection with Mr. Booze's paper[2] a statement was made that checker brick were commonly supposed to go at least to cone 31. I have seen some stiff-mud fire brick which I doubt would go above cone 27 or 28. These have been used with considerable success and a greatly reduced cost. In fact they gave much better results in the checkers than the first grade brick previously used.

It is a departure, I think from the usual practice. The men in charge of the plants said that their checkers cleaned up better; they had a larger percentage of brick that could be used over again when they put in their rebuilt checker work. That brick is made either in northern Kentucky or southern Ohio.

[1] Discussion conducted at Atlantic City Mtg., Feb., 1924 (Refractories Division).

[2] "Checker Brick for Resisting Alkaline Slags," *Jour. Amer. Ceram. Soc.*, **7** [8], 594 (1924).

MR. HOWE: The life of fire-clay brick depends upon the design of the furnace. For instance, in the Illinois district they are using machine made checker, made from Cheltenham clay which seems to give very good results and on the other hand there are lots of open hearth furnaces where they have to use brick fusing as high as cone 32 or 33 if they can get them and yet they do not always get satisfactory results. They have to top them off with silica checker. This can usually be traced back to the furnace designs and relative proportions of the different parts.

While the subject of checker brick is being discussed, it just occurred to me that some work was done in England a year or so ago regarding the effectiveness of the different portions of brick. They seemed to think that even with silica brick the outer edge was the only one varying in temperature during the regular period of the firing. In other words, $2^1/_2$-inch checker would give all of the efficiency that was necessary because that would leave a $^1/_2$-inch center to give a certain amount of solidity to the structure. The conclusion reached in this paper was that it would be a fallacy to go below $2^1/_2$-inch checker and permissible to use only as thick a checker as would be consistent with solid construction.

MR. HEWITT: We have seen at times where the furnace operator, in constructing his checkers, would use two different types of brick—a higher fusing brick at the top eight or ten courses and a lower fusing brick for the lower courses. We have also found at other plants that the practice is to use one grade throughout the checkers, the point being that from an operation standpoint there was too much danger of getting the brick mixed, when they are being laid. It will be interesting to learn whether or not the practice varies from district to district and which of the two is the more common method.

MR. DELL: We have made checker brick with cone 28 refractoriness which gave good service over a number of years. Whenever they have had slag flashes or too much slag that was carried over, these bricks failed through this slag action.

What type of checker brick seems to give the best service; those ground fine and fired hard or those of a medium grind with a medium fire? It has been our experience that as long as the brick were well fired with a good medium firing, it did not make much difference whether they were very hard or not. In other words, the surfaces on hard fired and that of medium fired brick were about the same.

Mr. SPANGLER: I would like to discuss the use of silica brick with particular reference to the problems of the furnace roof.

One speaker mentioned that if the life of roof brick could be increased the open hearth furnace would be greatly benefitted. Before we get to the problem of increasing the roof life we need to consider the elimination of the minor repairs of the roof. These repairs during the course of

a run, hamper the whole operation of the furnace. If the furnace is shut off every little while, for 20 minutes to an hour, for a roof patch, allowing the furnace to cool a bit, a fatigue strain is set up in the roof brick which probably increases the spalling rate and tends to reduce the total roof life.

If the refractory men could produce brick having a uniform life in all parts of the roof (and the rest of the furnace as well) throughout the life of the furnace, we then could consider lengthening the whole time of the furnace run by lengthening the life of the roof.

Minor repairs cost labor, material and furnace time. Of these three items, the greatest is furnace time, for an idle furnace means lost production. Mr. Cornell[1] gave a very complete discussion of furnace costs but apparently neglected to consider *lost furnace time*. Minor repairs, occurring in small driblets here and there, amount to a great deal of money in the yearly cost and constitute a considerable item in the cost per ton of steel produced. Refractory men can be of great help to the furnace operator by producing uniform quality of brick thus making possible fewer minor repairs.

Mr. Harrison[2] mentioned in his paper that lack of uniform physical structure of the brick has an effect on the need of roof repairs and on the final failure of the roof.

The fact that roof brick are not smooth and uniform in surface causes them, when placed in the roof, to crack. At the start of the furnace run the operator gets a nice glaze over his roof and in a few days (sometimes a week) a few ends of roof brick drop out. The glaze on that place is lost. The furnace is operating at its highest heat and that spot begins to weaken and burn and in a very short time minor repairs are necessary at that part of the roof. If the brick are a little warped they will likely be cracked when building the roof.

The masons have to build the roof as fast as possible to get the furnace back into production. They are not doing a fine piece of work such as is done on a fancy public building but are getting the roof in place as quickly as possible because an idle furnace means money lost. It means the biggest portion of the furnace cost. As a result the brick are put into place as hurriedly as possible. Warped surfaces are often placed next to each other instead of slowly fitting the concave and convex surfaces together. The load comes on the roof when the roof form is taken out and the lower part of warped brick is likely to crack. They may not drop out until the end or the first week but they will sooner or later cause weak spots which lead to roof troubles.

[1] "Some Considerations Necessary in the Selection of Refractories for the Open Hearth," *Jour. Amer. Ceram. Soc.*, p. 670.

[2] "Roof Brick for the Open Hearth," *ibid.*, p. 698.

The manufacturers can increase the life of the open hearth furnace, not only in the roof, but in many other places by producing brick uniform in shape.

MR. CORNELL: Natural gas furnaces may lose 15 days production in the course of the year for rebuilding and producer gas furnaces may lose 20 days.

In the million-ton plant which I described, the loss of tonage due to open hearth not being a permanent structure is about 80,000 tons per year. That totals up to a big sum of money. One half of the lost time is caused by rebuilding and one half to operating delays.

MR. GRIFFITH: A silica brick wall fails first at or near the slag line or immediately above the basic material.

Frequently the top wall at a certain plant would be perfectly good while the center portion would be useless even for salvage. They put in lump chrome for backwall about 22 inches thick at the bottom and tapering back to about 8 inches. They very rarely replace the bottom. That backwall costs them a little over twice as much as an original new silica wall. It lasted them four times as long. The top wall was patched along the skew-back. I saw a front wall last week in that plant that just had the one hundred third heat. The wall was perfectly good. You could almost lay your hand on the bottom. There were a few little red spots along the skew-back. They would replace those little spots and thus get full life of furnace out of each wall.

One particular plant, visited recently, had one furnace on oil. They had trouble with their bulkheads. They seemed to melt them right down on the outgoing end. That, reversed, gave them the same trouble on both ends. Their oil pressure was about the same pressure as that of their air. In other words, to atomize their oil they were using air which should have been used only for combustion, and consequently were blowing their fire clear over to the bulkhead. They blamed that on the brick. That was the first impulse. The brick had nothing to do with it.

MR. HOWE: I wonder whether chrome brick would be satisfactory in the front wall of the Talbot furnace.

MR. GRIFFITH: That constitutes the roof when you are tapping. There is some possibility of using chrome brick in that type of furnace. They have tried magnesite brick. While we have improved considerably the physical strength of chrome brick, I doubt very much if it would give them any better service than they have had with magnesite. The spalling would be very much less but I do not believe their trouble is due either to spalling or fusion. I think that it is due primarily to the fact that that is a suspended roof with nothing to hold it but the brick at top and bottom. No brick will stand in there unless they tie it in some way or arch it as in a roof. You would not build a roof of an open hearth furnace upright,

then turn it over and expect to have a perfectly flat roof which would stay there. That is literally what you do when you tilt a Talbot furnace. You have not provided for a roof. That is not the fault of the brick. It is the fault of the designer.

MEMBER: Is the failure of silica brick due to the structure of the brick or to the rapid heating up?

MR. SPANGLER: The too rapid heating up of a new roof will always cause failure. If we get a shorter roof life than our long series of records leads us to believe we should get, we then investigate the cause of the failure. The irregular brick structure of silica brick is the final cause of patching in a roof. The irregular structure is one of the causes of patching a roof, one of the things that makes necessary minor repairs. Ceramists and refractory engineers might make wonderful brick as far as nonspalling is concerned, but if the manufacturer turns out that same brick in warped and non-uniform shape, the furnace is not going to be much better off. That is what happens with a good many of our silica brick today. The brick are not regular in structure. In the arch they bear the load of the weight of the whole arch. Strains are set up when two concave surfaces of adjacent roof tiles are facing each other. Something has to give way. Those warped brick give way sooner than brick which have surfaces uniformly in contact with each other. I look upon that as a manufacturer's problem for which the open hearth operator pays.

MR. BOLE: Mr. Howe, do you consider that there is any chance for improving mechanically the shape of silica brick? Are there any possibilities in the mechanical molding which is now being developed?

MR. HOWE: Silica brick are being made now by machine. They were made a good many years ago by the die process but the results were not entirely satisfactory. It was tried in this country at the Niles plant and abroad in England. Die pressed silica brick were never popular but more recently they have developed a machine which more closely duplicates the hand process. The material, instead of being thrown in by the molder, is dropped. The force of the drop is equal to the force which the molder would give when throwing the material into the mold. In that way the mold is filled out properly. It gives some trouble in getting absolute uniformity in the amount of material that drops into the mold to fill out the shape, but under careful control it is possible to make a silica brick that may be used interchangeably with a hand-made silica brick. One company is now building a larger machine and three other companies are figuring on new installations. From that it seems that the advent of the machine-made silica brick is here.

MR. AYARS: Occasionally a piece of brick drops out. Is that more often caused by irregularity in the shape of the brick or is it because of a slight crack in the brick due to rough handling in transit or by the mason?

MR. SPANGLER: It is not caused by an original crack in the brick. The brick mason taps each brick with his hammer as he puts it in place. If he found a brick with a punky ring, indicating a crack or internal defect, he would discard that brick.

MR. AYARS: Do you exercise rigid inspection as to shape of your brick?

MR. SPANGLER: We do not, because there has been no acceptable specification for silica brick universally used. One thing I think the AMERICAN CERAMIC SOCIETY is going to do for the brick consumer is to put before the manufacturer and consumer specifications which we will agree are working specifications. These will be the basis of inspection.

When we receive a carload of brick which does not look good to us (and I say that advisedly because that is our main means of detecting poor brick), we test some of them chemically and physically. Then we have an argument with the brick company. We send them some and say that the brick ordered were first class brick. What constitutes first class brick? We have heard that discussed here in the meetings a good many times. Ultimately the consumer hopes that the problem of specification will be ironed out and that there will be a common measuring stick for everybody to go by in the acceptance and rejection of brick.

MR. AYARS: In the case of silica brick I believe that the consumer is absolutely justified in requiring a brick that we can put a straight edge on—across any corner or from side to side.

MR. SPANGLER: We are unable to get such brick from the manufacturers.

We would like to ask the manufacturer to give us a certain percentage of brick which would stand a straight edge diagonally—what that percentage should be we hope the Specifications Committee will sometime tell us. We could not ask the manufacturers to give us 100% straight. They would in turn ask us if we wanted the brick goldplated.

MR. AYARS: The average manufacturer of silica brick is trying to furnish a straight brick but there are many operating details in a silica brick plant that get away sometimes and crooked brick may result. Is there a hammer inspection of each brick as it is laid? Do you use a $13^1/_2$ inch roof?

MR. SPANGLER: $13^1/_2$- and 18-inch rings.

MR. AYARS: The average open hearth roof is laid under the direction of one good mason by labor that commonly shoves a pick.

MR. SPANGLER: Our roofs are laid by experienced brick masons.

MR. BELL: Premature failure of an open-hearth roof may at times be traced to the breaking or spalling of even a very small number of brick, or as it is sometimes called, unit failure. The end of a single brick becomes detached by spalling and falls out. A hole or pocket is thus formed

in the roof and the adjoining brick are then the more readily attacked by the furnace gases.

One defect which has not been mentioned is that of sponginess or poorly filled out brick. Brick with spongy corners are naturally weak and hence more liable to spalling and failure under load. Brick to best withstand open hearth service should not only be true to shape but also of sufficient mechanical strength to support the structural loads imposed upon them.

MR. NESBITT: A large part of Mr. Spangler's troubles are due to poorly shaped brick. The mechanically made brick are true to shape. The hand-made brick are not always that way. Mechanical brick can be placed on one end 5 or 6 feet high without toppling them over. You cannot do that with hand-made brick.

In nearly all cases where the brick pinch off and start a place in the roof such as Mr. Spangler described, it is really chargeable to want of trueness in shape of the brick.

If a large particle of ganister gets into a brick it is needless to say that when it starts to heat, its expansion is not going to be the same as that of the brick. It pinches off a piece of the brick. There will be a weak place in the roof right away.

MR. AYARS: There are other things besides molding which enter into the shape of the brick. Chief among them is the shape of the pallets on which they are dried. If these are not perfectly smooth and true the brick will be warped. That will happen in a mechanically made brick although the edges appear to be true. The pulling of the end of the brick is hard to get away from in hand molding but I believe that a perfectly true brick as far as the two flat surfaces and edges are concerned, can be made by hand molding. It is the fault of the pallet or of the moving of a car from the molding table to the drier that dictates the shape, particularly with silica brick.

DR. MACK: It is not exactly clear to me why the spalling or dropping of a comparatively thin piece from the silica roof in the open-hearth should result in its complete failure. From Mr. Spangler's remarks, he considers this connected with the breaking of the continuity of the glazed surface previously produced when a new roof is put on and brought gradually up to operating temperature. A smooth glazed surface is evidently a desirable condition to have but just why the falling out of a small area, 3 inches thick, from a thirteen or eighteen inch roof should bring about failure is not quite clear to me. I wonder if I can get a little more enlightment. Is subsequent "burning-out" due to chemical erosion, mechanical abrasion, or some other action? I would like to get straightened out on the physical chemistry of the process by which the roof is brought to failure.

MR. SPANGLER: When a 3-inch piece of one tile drops out, leaving a break in the glazed surface of the roof, there is exposed to the flame at the highest temperature the bottom part of that raw tile as well as 3 inches of side surface of the surrounding brick. Those brick have no chance to glaze because they are not heated slowly. The furnace is operating at its fullest extent, therefore spalling takes place and actual burning of the brick represented by dripping. In a short time a hole appears in the roof at that place. That hole must be patched. The patch is fresh brick which have no chance to become glazed. The furnace has been shut off only 20 minutes while that patch is put in. In a few minutes it is back again operating under full heat. The new brick then begin to spall; they do not have a chance to glaze. That continues on in that one place, and many other places like that throughout the roof, until the roof finally fails.

DR. MACK: After spalling takes place you do not get re-established the glazed roof surface but you do get actual fusion and dripping from the unglazed area exposed. This would be convincing if it could be shown that the material at the uneven surface exposed by the spalling actually had a lower fusion point than that of the vitreous material making up the remainder of the roof surface.

MR. SPANGLER: I believe so but I cannot prove it.

MEMBER: If 3 inches of brick fall out the support of adjacent brick is gone. They also will break off and in no time there is quite a hole in the roof. It is generally accepted that every joint in a wall, especially walls of open hearth furnaces is a point of attack; that if we could have a wall of one piece with a perfectly smooth surface to start with and could keep it from cracking, that wall would last longer than a wall made of a number of units of the same material.

One of my open hearth friends performed a very interesting experiment which has a bearing on this. He built the two opposite ends (the bulkheads) out of brick. They were exactly the same excepting that for one end of the furnace he went to the expense of grinding the brick until they were brought to absolutely true surface, such as you might get with machine made die pressed brick. Those were laid in place without any mortar joints whatever. The bulkheads in the opposite end of the furnace were built up of ordinary brick as they came from the manufacturer, using the regular practice of laying up. They used these brick in opposite ends of the furnace in order that they would be subjected to exactly the same treatment and get a real comparative test. The net result was that the brick that had been ground to true surface lasted out five times the brick in the other end. The brick that were not ground to true surface had to be replaced five times before the others did. This, however, was in a small furnace.

MR. DORNBACH: From the standpoint of manufacturers, symposiums

are very welcome. Next to seeing the special requirements, I know of nothing better than to listen to remarks passed out by the users of refractories. The manufacturer has a terrific amount to contend with because everybody in the manufacturing game knows that in different places you meet different conditions where you are supposed to find practically the same thing existing.

MR. CORNELL: Mr. Spangler brought out some very important things in the discussion of handmade and machine-made brick. The A. S. T. M. have gone into this quite thoroughly but I do not think the metallurgist is a ceramist. Mr. Spangler says we must get together, the ceramist and the steel man, and get a set of specifications that will suit everybody. How are we going to get that set of specifications? The A. S. T. M. may compile one but that does not mean that they will be accepted.

MR. SPANGLER: I might say that we have paid very little attention to spalling tests in our own experimental work because we have felt that spalling is tied in with other tests which are more conclusive such as the chemical analysis, the apparent specific gravity and porosity. Those three items have a certain control over spalling and we admit, without being able to remedy it, that spalling occurs wherever expansion and contraction occur. The minimum amount of expansion and contraction will give the minimum amount of spalling. We know that to be a fact and have no way of getting around it. We have paid very little attention to spalling tests in our own work. We have just observed relative spalling of various kinds of brick and have tried to get those which showed the least amount of spalling.

MR. GRIFFITH: If a brickmaker has a brick that gives in the open hearth 318 heats where he has been getting an average of 215 heats, and pleased to get that, and he asks one dollar per thousand extra, you quit buying his brick. Where, then, is the incentive outside of the personal pride in making the brick to give you the service you think you ought to have?

MR. SPANGLER: Mr. Griffith has mentioned a very vital point and one which I think the brick consumer will have to fully appreciate and realize if he is going to get proper coöperation from the manufacturer. We think, in our own plant that we have realized that because we are basing our requests for brick to the purchasing department on the results of our records of service life in cost per ton of steel rather than in dollars per thousand of brick delivered to the plant.

MR. ROSS: Glass manufacturers feel that frequently in the crowns of glass melting furnaces a good deal of the breaking of the brick in the heating of the crown is due to non-uniformity of the firing of the silica brick. Some of the brick have been fired hard and hence have a given expansion and some of the other brick in which the quartz has not been

transferred to the other forms of silica will continue to take on further permanent expansion. Do you find that irregularities in the firing of silica brick bother you any?

MR. SPANGLER: We have not observed that in roofs. But I believe such a condition would lead to trouble.

MR. MATHESON: Mr. Spangler has brought out many points that have given us all trouble. We have had our trouble with spalling. We call it gobbing. Mr. Spangler referred to it as brick defects. There is a whole lot in the way a roof is laid up. If the brick are not keyed up properly the tendency is for the roof to sag leaving the bottom part of the joints unprotected. The entire strain or weight of the roof is on the outer part of the brick and then the defects that Mr. Spangler refers to will occur. Any silica brick when brought up to heat is going to show defect on account of its high coefficient of expansion. On the other hand if the turnbuckle rods are tight, expansion will raise the roof, opening up a portion of the joints and throwing the entire weight of the roof upon the lower portion of the brick and then spalling will occur due to a shearing action which has been brought upon the brick. This may not be 100% our practice. It is my belief, however. I have tried it and it works all right.

The brick are laid in dry, driving in a tight key. We gage the most of our brick before we put them in. We submit them to a visual inspection. We always take some brick from the cars and send them to the laboratory for physical and chemical analysis. We instruct the men to be careful that that key fits both top and bottom. We try to get the key in so that it takes uniform bearing from the very top of the brick down to center before we take out the wooden centers. We have our men under the supervision of competent foremen.

MR. HOWE: Mr. Matheson, where a portion of the roof was raised more than another as cited by Mr. Ross are the strains or different pressures causing this due primarily to volume changes within the brick?

MR. MATHESON: I never noticed that to be the case where a section of the roof went up higher than another. If we find light colored brick in our roof we take them out. We do not as a rule put any light colored brick in the roof.

MR. AYARS: Mr. Matheson spoke about gaging the brick. Do open hearth operators gage brick received or possibly just before putting them into the roof? Do they put a straight edge on them?

MR. MATHESON: We have a standard method of gage inspection. We allow a tolerance of under or over a certain per cent. That we are not as particular about as the uniformity in thickness. Sometimes we find a carload of brick that runs slightly over $2^1/_2$ inches in thickness. Others will run slightly under. When those brick are uniform throughout the entire carload, whatever the lot consists of, then, we consider them as satis-

factory. We always gage our brick as to uniformity and as to straightness. We do not gage every brick in the car but we take them out here and there and at random and gage them. If we find too many in the car that are warped or do not show even corners, then we go through the car very thoroughly. If we find the first 8 or 10 brick are satisfactory we accept the car as being O. K. The same applies to uniformity and thickness. We allow a tolerance of $^1/_4$ inch per foot.

MR. AYARS: Would you prefer them to be a little under thickness than over if you are going to have a variation?

MR. MATHESON: I have never paid attention to that.

The matter of glazing has also been discussed here. We experimented somewhat with that. It is not the temperature of the furnace that causes the glazing. The fine particles of the brick are worked to the surface, to what is known as the skin of the brick. The surface of the brick will vitrify where the porous interior of the brick will not. If a half brick is suspended in a furnace, the portion of the brick containing the original skin will glaze where the fractured surface of the brick will not.

MR. BROOKS: It would be interesting to know what service tests for refractories the open hearth men are using to determine proper applications of refractories to their needs. Certain practical operating tests were mentioned. What is the nature of such tests?

MR. SPANGLER: We first make laboratory tests as is done in any laboratory and then we install the type of brick we are experimenting with in a section of the furnace right beside the type of brick which has been previously used and with which we are acquainted. Then we observe that test installation every day as long as it lasts and make complete notes on its history. At the end of its life we can compare it with our experience on the type of brick which we are using in that particular place.

MR. FURNESS: There is no question but that an open-hearth operator will run his furnace to the maximum temperature that the brick used in the construction of the furnace will endure. That part of the furnace which is most vital, and the failure of which causes the longest repairs, and the most expensive repairs, even at times going into a general repair, is the roof. Therefore, since, in the course of the discussion it has been mentioned that certain standard silica brick will, on account of their perfection as to shape and manufacture, give greater endurance, the open-hearth man would like to have these produced as a special quality brick for roofs.

Further, if there is any method by which the ceramic engineers can increase the ability of these brick to resist high temperatures, this should be applied to the manufacture of these special brick. I feel, however, that there are many other problems of nearly equal importance to the brick used in the construction of an open-hearth furnace, on which much help could be given to the steel manufacturer by the AMERICAN CERAMIC

SOCIETY. For example, runner-brick, sleeves and nozzles—the latter in particular. The difficulty of obtaining a material which will resist the erosion of the steel at the high temperature at which it is poured is certainly great, and, at times, one is discouraged by the inability to obtain the material which in any way approaches that which one would desire. So far, I know of no nozzles, runner-brick, sleeves or ladle linings which are satisfactory.

All of these remarks apply to the manufacture of "quality" or high-grade steel. While important, they are not of such vital importance in the "tonnage" plant as in a plant which manufactures only "quality" or high-grade material.

I regret that the suggestions which I can offer to improve the conditions, are very few, but feel that, if any good ceramic engineer devoted a little time to the matter, he could improve all runner-brick tremendously. It must not, however, be lost sight of that these brick must be produced at a minimum cost.

I do not, at present, know of any clays, or clay-brick, which are used in ladle linings which are not strongly acid, yet one expects these to resist hot basic slags.

Considering nozzles, the importance of this piece is evident, particularly where it is necessary as in "quality" material to have a good control of the stream. Yet, but little attention is paid to the material, and still less to the waring and increase in size of opening.

I would suggest a brick for ladle lining which has a neutral or basic reaction when hot; for nozzles the material should be one that would resist the erosion of hot steel.

DISCUSSION ON THE DISINTEGRATION OF CLAY REFRACTORIES IN IRON BLAST FURNACES

BY S. M. PHELPS

The disintegration of iron blast furnace linings has been studied by Nesbitt and Bell.[1] They found that, under certain conditions, iron oxide in clay refractories acts as a catalyzer, by converting the carbon monoxide of the furnace gases into carbon dioxide and free carbon. The carbon is liberated where catalysis occurs, thus forming a deposit about the nucleus of the iron compound. This deposit of carbon gradually grows and in time acquires sufficient size to disrupt the structure of the brick. The deposits in the brick vary in size from those hardly visible to half an inch or more in diameter. The carbon is usually of a soft soot-like nature, but at times assumes a graphitic character.

In practice, the degree of disintegration varies from small cracks to

[1] *Iron Trade Rev.*, 1603–1607 (1923).

complete disruption, forming a dark gray sand-like material. It occurs in zones about parallel to the inner surface of the lining and varies in thickness from a few inches to a foot or more. In areas of disintegration, a perfectly sound brick is often found, which at the present time has not been satisfactorily explained.

Disintegration is often a contributing cause for "blowing out" a furnace, but rarely a direct one. It seems to be more prevalent today than 15 to 20 years ago.

The results of the experimental work on this subject by Nesbitt and Bell may be summarized as follows:

1. The iron oxide must be in an uncombined state to be catalytic.
2. Catalysis begins at 300°C and continues until 525°C, being most active at between 420 and 470°C.
3. The higher the concentration of the carbon monoxide in the gases, the more pronounced the action.
4. The higher the percentage of free iron oxide, the greater the disintegration.

Nesbitt and Bell found that brick made by the auger machine fracture along the lamination lines, steam-pressed brick split lengthwise, while hand-made brick fracture very irregularly.

Suggested Preventive Measures

Inasmuch as the gases of the blast furnace cannot be changed, the remedy must be in the refractories.

The ideal brick would be made of clays free from uncombined iron oxide. As an alternative, the ordinary clays could be treated to remove the objectionable iron compounds by weathering or otherwise.

Hard-burning affects the solution of iron compounds, thus destroying their catalytic property, but may make the refractories too sensitive to thermal shock.

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[1] The abbreviation (*C. A.*)at the end of an abstract indicates that the abstract was secured from the editor of *Chemical Abstracts* by coöperative agreement.

Cement, Lime and Plaster

Calcium sulphate cement. C. L. HADDON AND M. A. W. BROWN. *J. Soc. Chem. Ind. Trans.*, **43,** 11T–16T(1924).—The principal objects of research were: (1) To det. the number of allotropic modifications of anhydrous calcium sulphate; (2) To explain differences in setting properties of calcium sulphate from different sources; (3) To exam. the acceleration of setting by other sulphates; (4) To investigate the nature of intercryst. adhesion. (1) Van't Hoff distinguished two forms of anhyd. $CaSO_4$, one of which he called "sol. anhydrite." H. and B. conclude that only one modification of $CaSO_4$ exists; its soly. at 33°C is 2.29 g. per l. and in 5% copper sulphate soln. 2.08 g. per l. (2) The diff. setting rates of diff. plasters are due to particle size and percentage of hemihydrate. Flooring plaster consists of anhyd. $CaSO_4$ and hemihydrate. Anhyd. $CaSO_4$ absorbs moisture from the air to form hemihydrate, the speed depending on the particle size. Agglomeration of particles is increased by intensity and duration of heating. Growth of particles is due to the particles adhering and not to finer particles dissolving and repptg. The influence of external conditions is also shown. (3) Rohland's theory that salts which increase the soly. of $CaSO_4$ increase the setting speed and *vice versa* is shown to be incorrect. Borax, which retards the setting of plaster, increases the soly. of gypsum. $CaSO_4$ dissolves and ppts. more readily in presence of copper sulphate. (4) Rosenhain enunciated the theory of the existence of a powerful intercryst. cement, amorphorus in nature, and F. C. Thompson put forward an alternative surface-tension theory. The evidence obtained supports R. Setting is caused by the interlocking of needles of pptd. dihydrate, and by crystal adhesion due to amorphous cement which dissolves in certain solvents with corresponding loss of mechanical strength. H. H. S.

Magnesium oxychloride cement. J. H. PATERSON. *J. Soc. Chem. Ind.*, **43,** 215–8(1924).—Sorel's cement is the strongest cement available on a large scale. It can be made nearly twice as strong as Port. cement, and can bind together very large volumes of filling mats., such as sand for concrete or sawdust for floor covering. It consists of the compd. $3MgO.MgCl_2.10H_2O$ mixed with solid solns. of a more basic nature. If the temp. of burning magnesite is carried above 1000°C the resulting MgO will not react with $MgCl_2$. Chem. analysis cannot detect overburned MgO in a consignment; thus a mat. of satisfactory chem. compn. may be useless for cement making. $MgCl_2$ is best used at 22° Bé.; at 24° it causes the setting cement to expand and destroy the molds or blister the floor. The amt. of $MgCl_2$ added is only about half of the chloride reqd. to combine with the MgO. Specif. for the cement are suggested, viz: *Tensile strength* 500 lbs. per sq. in. after 7 days and 850 lbs. after 28 days, with a mixt. of 1 pt. MgO, 2 pt. fine ground SiO_2 and 5 pt. standard sand sufficiently wetted with $MgCl_2$ to be molded into standard briquettes of cement-testing machine type; *Wet strength* should not be less than 30% of dry strength; the briquettes are sprayed with water 3 or 4 times in 8 hrs. and then tested; *Setting time* is detd. with a Vicat needle; the initial set should not take place before 90 min. and the final set should be attained within 8 hrs.; *Expansion* if over 0.3% within 24 hrs. of initial set is questionable. Free lime in the MgO reduces the wet strength. (Ref. is made to Seaton, Hill and Stewart, *Chem. and Met. Eng.*, 1921.) H. H. S.

Magnesium oxychloride cement. H. H. DAINS. *J. Soc. Chem. Ind.*, **43,** 284 (1924).—D. questions Paterson's statement that magnesite is dead-burnt for cement purposes at 1000°C. A temp. of 1500°C would be required. H. H. S.

The Internat. Cement Congress (*Jour. Soc. Chem. Ind.*, **43,** 240(1924)).—Arranged by the Instn. of Structural Engnrs. in London, Eng. April 22 and 23, 1924, discussed the following subjects: (1) Cement fondu in practice, (2) surface dust on concrete floors in factories, (3) Cement in sea-water, (4) Cement in concrete roads, (5) Preparations to withstand oil, (6) Influence of size and shape in compression test-

blocks, (7) Microscopy of cement, (8) Porosity of concrete blocks, (9) Use of sea-water in mixing cement. H. H. S.

Cement and Lime Co. Works—(Queensland). ANON. *Indus. Aust. and Min. Jour.*, **71**, 659(1924).—Situated at Darra, 10 miles from Brisbane. Limestone obtained from quarries at Gore. A full description is given of the works and methods employed. The works now consist of 2 complete units capable of an annual output of approx. 60,000 T. per annum. O. P. R. O.

Super-cements. RICHARD GRÜN. *Zement*, **13**, 27–30, 39–41(1924).—Three types (1) the quick setting special portland cement, (2) high-calcium cements, and (3) high-alumina or cement fondu are discussed. In (1) only pure raw mats. finely ground and carefully burned, are used. In two days the strength attained surpasses the usual 28-day demands. Tricalcium silicate is probably the chief constituent. Group 2 depends upon the fineness of its raw material particles for its somewhat greater strength. The CaO content lies between 65% and 74%. In (3) calcium aluminates replace the usual silicates. The chief distinction from portland cement lies in the high initial set and the resistance to most salt solns. In some expts. with high-alumina (30%–50%) cements, G. explains the variations due to differences in burning as well as in the compn. The effect of cooling rates and modes is also studied. H. F. K. (*C. A.*)

Miscroscopic examination of raw and calcined gypsum. E. S. LARSEN. *Proc. Am. Soc. Testing Materials*, **23**, I, 236–43(1923).—A miscroscopic description including form of crystal, *n*, etc., is given for the minerals most commonly found in raw gypsum, *viz.*, gypsum, quartz, anhydrite, calcite, and clay. The changes which occur in these constituents during calcination are discussed and the $CaSO_4.{}^1/_2H_2O$ formed is described miscroscopically. A method for the estn. of anhydrite is given. J. C. W. (*C. A.*)

BOOKS

KLOES, J. A., VAN DER: **Onze Bouwmaterialen.** 3rd ed., 6 volumes. Amsterdam: L. J. Veen. Guilders 50.00. Reviewed in *Arch. Suikerind.*, **32**, 219(1924). (*C. A.*)

MENEGHINI, DOMENICO: **Chimica applicata ai materiali da costruzione.** Padua: Litotipo-editrice Universitaria. 279 pp. L. 25. (*C. A.*)

MÖRSCH, E.: **Teoria e pratica del cemento armato.** 2nd ed. revised. Mailand: U. Hoepli. 691 pp. L. 54. (*C. A.*)

PATENTS

Cement. R. DÉCOLLAND. Brit. 211,497, Feb. 14, 1924. Aluminous cements are made in ordinary rotary kilns by (*a*) lengthening the heating zone, and (*b*) preventing the formation of a coating due to the fusing of the fuel ashes. The lengthening of the heating zone is accomplished by employing as a fuel a coal such as lignite which contains a large proportion of volatile neutral products, or by diluting the roasting atm. with water-vapor or other neutral gas. The formation of a coating of fused ashes is prevented by mixing with the fuel a sufficient proportion of limestone to combine with the SiO_2, Fe, etc., and render the ash refractory, or by removing the refractory lining of the kiln at the point of formation of the fused ash, and cooling the plating by external means. (*C. A.*)

Slag cements. H. ANDREWS. Brit. 211,517, May 22, 1923. Lime, with or without other substances such as SiO_2 and Fe ore, is mixed with molten blast-furnace slag, and the mixt. is fed into a rotary kiln at 1500°. The waste gases from the kiln are utilized to burn limestone for the production of the lime used in the process. The clinker is ground with or without an addn. of 30–50% of granulated slag. (*C. A.*)

Preparing sawdust for use in concrete, etc. E. L. ZUKOSKI. U. S. 1,490,719, April 15. Sawdust is treated with a Na silicate soln. and then washed in order to remove substances such as would interfere with the setting of cement. Cf. *C. A.* **18**, 158. (*C. A.*)

Coated waterproof sheeting. L. KIRSCHBRAUN. U. S. 1,489,254, April 8. A waterproof material adapted for use as a *roofing* is formed of felted fibrous sheets satd. with a bituminous binder and coated on one side with bitumen, fiber and an emulsifying agent, *e. g.*, a mixt. of fiber, asphalt, clay and H_2O. Cf. *C. A.* **18**, 742. (*C. A.*)

Protecting wooden piling from teredos. C. P. TATRO AND G. DELIUS. U. S. 1,489,798, April 8. Submerged piling is protected from attack by teredos by placing an anode in the water adjacent the pile and passing a current between it and a more distantly placed cathode. (*C. A.*)

Terminal for electrolytic devices. G. DELIUS AND C. P. TATRO. U. S. 1,489,743, April 8. Structural features of a device for electrolysis of sea water to protect piling. (*C. A.*)

Road material. G. W. BUTLER AND C. WILLIAMS. Brit. 211,205, Nov. 13, 1922. The special ferro-silicate known as "copper slag" found in the neighborhood of Swansea is intimately mixed with a tarry or bituminous binder to form road macadamizing for paving material. The % compn. of the slag is SiO_2 60.6, Fe_2O_3 33.48, CaO 2.80 MgO 1.00, S 0.54, with traces of Cu and Sn. (*C. A.*)

Enamel

Japanning license plates. ELMER C. COOK. *Fuels and Fur.*, **2**, 695–6(1924).—Describes methods and equipment used in modern plants at state prisons for making motor vehicle license plates. W. E. R.

Unique pickling system—humidity driers cut costs in enameling plant. ANON. *Cer. Ind.*, **3** [1], 22(1924).—(The Columbian Enameling and Stamping Co., Terre Haute, Ind.)—Single coated grayware and triple coated whiteware are produced. Small wooden carts are used to carry the raw mats. from the bins, over the scales to the rotary mixer in 1500-lb. batches. The batches are mixed for 2 mins. and elevated to 12000-lb. storage hoppers. A conveyor bucket carries the mixed raw mats. in 1100-lb. batches to the smelting room. The smelting is done in 2 tilting rotary furs., the combined daily capacity of which is 9 batches of 850 lbs. each, the time required being $2^1/_4$ hrs. The frit storage bins are calibrated in order to facilitate the taking of inventory. Fourteen 5-ft. ball mills are provided for frit grinding. The frit is ground in 1000-lb. batches until a test shows it has been ground sufficiently, which requires about 10 hrs. The test is made by drawing a 100 cc. sample of enamel, through a one-inch pipe inserted permanently in the mill, mixing it with a given vol. of water and allowing it to settle in a graduate for one min. The ground enamel is unloaded from the mills with the aid of compressed air into zinc lined carts which transfer the enamel into storage tanks in the dipping room. The annealing of the metal which is necessary after two or three draws is done in a continuous furnace at 1500°F. The completed metal shapes are sent through a continuous scaling furnace at 1300°F. Dovetailed wooden pickling baskets are used, each having an average capacity of 100 pcs. of ware. Rubber straps and a hand windlass are used for lowering and raising the baskets. The ware is kept in a sulphuric acid bath for 10 mins., rinsed in water and placed in a soda neutralizing bath. The acid tanks are built of 3-inch cypress with pitch-calked joints. The soda and water tanks are built of 2-inch pine with calked joints. A chain drier conveys the carts of pickled ware into the dipping and spraying room. The enamel is fed to the spray guns under a four foot gravity head and atomized with an air pressure of 80 lbs. Individual dipping and spraying booths are used. The triple coated ware is dried in driers at 180°F whereas the grayware is dried in the open. Each of the eight driers holds six trucks with a combined capacity of from 1200 to 1500 pcs. of ware. Ware requiring from 2 to 3 hrs. to dry in the open are dried in 15 mins. in the drier. There are twelve coal fired furnaces of the recuperator type equipped with fire-clay muffles

and carborundum hearths. The grayware is fired at 1700°F, the triple ground coat at 1750°F, and the cover coats at 1600°F. An optical pyrometer is used to measure the temp. All furnaces average 15 loads per hr. and operate on a 24 hr. schedule. The furnaces operg. at 1700°F produce 6 tons of ware every 24 hrs. on 3600 to 4000 lbs. of Indiana coal screenings bought at $2.00 per ton. P. D. H.

The second annual report of the British Cast Iron Research Association. Pp. 19. Birmingham, Eng.: The Birmingham Printers, Ltd. 1923. H. H. S.

Glass

New process anneals window glass in ten mins. ANON. *Cer. Ind.*, **3** [1], 17 (1924).—(Interview with Mr. Frank Bastin, Pres., Blackford Window Co., Vincennes, Ind.) This is the first plant built especially for the manuf. of window glass by the Fourcault process. Belgian glass experts have been employed. A plant is maintained for the manuf. of their own refracs. The raw "debiteuse" mixt. is ground in a dry pan to pass 16-mesh, pugged several times and stored in masonry bins. The "debiteuse" are dried for 3 mos. in an open room and fired to 1900°F in 6 days. Modern bins for the storage of raw glass mats. have a combined capacity of 44 cars. The unloading is done mechanically. The raw batch is gathered by an elec. operated car containing a mixing mill and scale. The batch is mixed for 5 mins. and elevated to a 43-ton capacity batch hopper also provided for cullet storage. Fifteen batches of 1500 lbs. each are fed to the furnace daily. The tank proper is composed of 2 tanks built in the shape of the letter "T" and connected by a canal. The dimensions of the melting tank are 21′ x 85′ by 5 blocks in height. The height of the glass in the drawing tank is 36″. The tanks are water and air cooled. The melting tank has a capacity of 800 tons of molten glass. It requires 72 hrs. for the glass to reach the machines. The melting temp. is 2650°F, the temp. in the canal is 2100°F, and the glass is drawn from the feeder tank at 1900°F. The special machines, which are set in a vertical position, may be regulated to draw glass of any thickness from $^1/_{16}$″ to $^1/_2$″ by changing the speed of the asbestos rollers. The sheet is 44″ to 52″ in width. The glass is annealed in a 20 ft. leer and acquires a beautiful natural polish. Four operators watch each machine, two the drawing and two the annealing process. Two men attend to two machines on the cutting floor. The fuel used is producer gas. The coal is crushed to nut size for the producers and the oversize is used under the boilers in the development of their own elec. power. P. D. H.

Determination of glass ware temperatures. JAMES VOORHEES. *Fuels and Fur.*, **2**, 679–81(1924).—For detg. the av. temp. of pieces of glass ware leaving the mold, or calcg. heat lost by ware between mold and leer, the construction and opern. of a simple calorimeter is described and the calculations involved explained. W. E. R.

Some notes on pot-clays and the manufacture, use, and treatment of glass-house pots. PERCIVAL MARSON. *Jour. Soc. Glass Tech.*, **8**, 29, 45(1924).—The author relates some of his experiences with glass-house pots and pot-clay mixt. The requisite characteristics of a pot clay are outlined and several tests are given. A combination of the treading process and the pugmill process is recommended for tempering. Methods of mfg. pots, arching pots, setting pots, and the prevention of stones in pots are given. J. G. P.

Specifications for glass. W. E. S. TURNER. *J. Soc. Chem. Ind.*, **43**, 92–93(1924).—The charge that glass splinters from food containers is a cause of appendicitis and cancer is, after consultn. with leading pathologists and surgeons, very definitely refuted. H. H. S.

BOOK

Directory for the British Glass Industry 1923. Soc. of Glass Technology, Sheffield. Price 7S. 6d.—Alphabetical list of glass mfrs., makers of scient. and optical app., crafts-

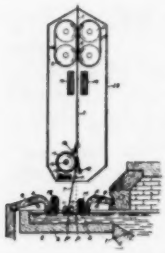
men, firms making plant app. and raw mats., trades unions and other assocns., and periodicals abstracted. H. H. S.

SCHULZ, HANS: **Das Glas.** Kempten: Kosel & Pustet. 180 pp. (*C. A.*)

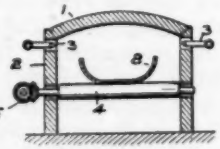
ZSCHIMMER, EBERHARD: **Chemiebüchlein des Glasschmelzers. Zum Selbstunterricht.** Jena: Thuringer Verlagsanst. u. Druckerei. 86 pp. (*C. A.*)

PATENTS

Drawing and flattening sheet glass. CLIFFORD A. ROWLEY. U. S. 1,499,406, July 1. In an app. for drawing and flattening sheet glass, a receptacle containing a mass of molten glass, means for drawing a continuous sheet of glass upwardly therefrom, a deflecting member for the sheet positioned between the molten glass and the drawing means, and having its sheet engaging surface in vertical alignment with the sheet engaging surface of the drawing means, and a pair of coolers one at either side of the sheet source, the cooler at the side beneath the deflecting member having the greater heat absorbing capacity.



Process of flattening glass sheets. HARRY G. SLINGLUFF. U. S. 1,497,798, June 17. A process of flattening sheets of glass having polished surfaces and a curvature which it is desired to remove and in which the glass has a temp. below that at which it sets, which consists in moving the sheets continuously ahead in a heated chamber on constantly shifting points of support, exposing the sheets to a temperature such as to cause them to flatten of their own wt. and then exposing the sheets to progressively decreasing temp. to permit them to set as they move along.



Process of flattening glass sheets. HARRY G. SLINGLUFF. U. S. 1,497,799, June 17. The process of flattening a parti-cylindrical sheet of glass which consists in moving the sheet continuously ahead endwise with its convex sides down on constantly shifting points of support, exposing the sheet to a temp. such as to cause it to partially flatten of its own wt. then applying pressure downwardly on the sheet along constantly shifting lines to further flatten it, and exposing the sheet to progressively decreasing temp. to permit it to set as it moves along.

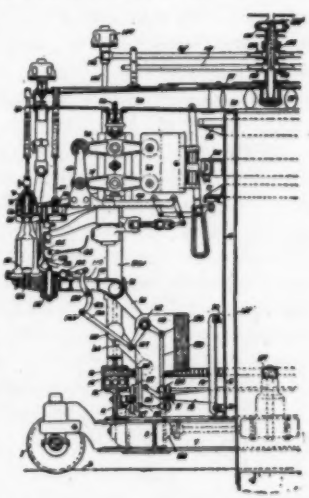
Glass-molding machine. WILLIAM G. BERGMAN. U. S. 1,499,334, July 1. The combination with a glass fur. having a discharge neck of a glass molding mach. having a set of finishing molds on each side of said neck, a single blank mold for each set of finishing molds, means for intermittently reciprocating said blank molds constructed and arranged to cause the blank mold for each of said sets to be reciprocated into alternate engagement with said discharge neck and its respective finishing molds to deliver a charge of molten glass to said finishing molds, means to release said charge from said blank mold as it is moved into engagement with its respective finishing mold, means to move said finishing molds into position to be engaged by said blank molds simultaneously with the movement of said blank molds, means to hold said finishing molds against movement during the stoppage of reciprocation of said blank molds, and means to admit fluid pressure alternately to each set of said finishing molds while said blank molds and finishing molds are stationary.

Machine for the manufacture of glass articles. ROBERT FREDERICK HALL. U. S. 1,499,522, July 1. In a mach. for the manuf. of glass articles, the combination of a fixed base, a ring mounted rigidly upon the said base, the said ring forming a lower

member of an anti-friction bearing, another ring rotatable with respect to the first mentioned ring and forming the upper member of the anti-friction bearing, hollow columns mounted upon the second mentioned ring, hollow radial arms in connection with the said hollow columns, such radial arms being also connected to an air supply, mechanisms carrying a parison mold mounted upon the said hollow columns, downwardly extending hollow forks in connection with the hollow radial arms, such forks being provided with apertures to enable cooling air to be supplied to the outside of the molds and parts to be cooled, and means for cutting off the supply of cooling air at appropriate times, substantially as described.

Machine for the manufacture of glass articles. ROBERT FREDERICK HALL. U. S. 1,499,523, July 1. A machine for the manuf. of glass articles comprising a stationary frame, a rotatable frame supported thereon, said rotatable frame including an upper member having a plurality of laterally extending radial arms, and a lower member, a removable vertical column interposed between each radial arm and the lower member and connected therewith, each of said columns having a vertically elongated opening therein, a parison mold supporting frame journaled in means in the elongated opening, a parison mold thereon, a finishing mold carrying frame journaled in the elongated opening, a finishing mold carried thereby, and means for effecting the actuation of the parison and finishing molds, the arrangement being such that when one of the columns is removed, the parison and finishing molds and their associated parts may also be removed independently of the similar parts carried by the other columns.

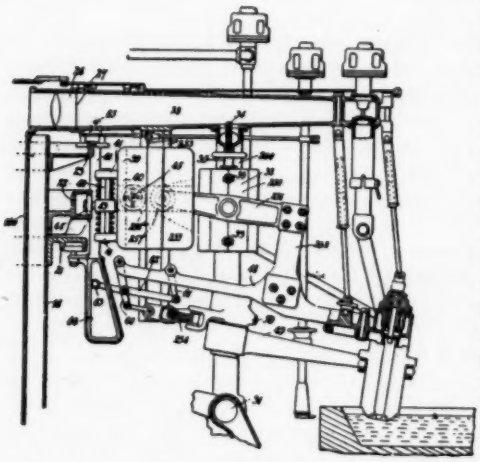
Machine for the manufacture of glass articles. ROBERT FREDERICK HALL. U. S. 1,499,524, July 1. In a rotary mach. for the manuf. of glass articles, the combination of a rotatable framework, rotatable about a fixed central column, a secondary frame adapted to slide vertically with respect to the said framework, in order to adjust the machine for parison molds of different lengths and for different levels of the molten glass, means for so adjusting the said secondary frame and for retaining it in various vertical positions, two levers of the first order, of equal length, one pivoted above the other to the said secondary frame, a link pivotally connected to the outer ends of the said levers, another link pivotally connected to the inner ends of the said levers, so as to constitute a parallel link lever mechanism of the first order, a sectional parison mold carried from the outer link, means operg. upon the inner link for lowering and raising the parison mold at appropriate times, such means being adjustable in order to regulate and accommodate the dipping according to the various adjusted positions of the secondary frame, substantially as described.



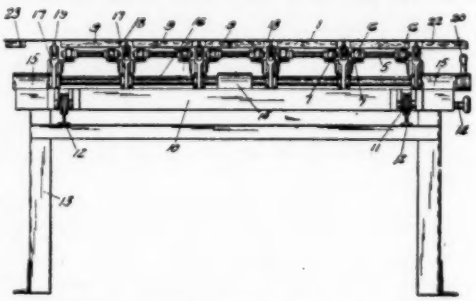
Machine for the manufacture of glass articles. ROBERT FREDERICK HALL. U. S. 1,499,525, July 1. In a mach. for the manuf. of glass articles, the combination of a rotatable framework, a lever of the first order pivoted to the said framework, a sectional finishing mold carried by the outer arm of the said lever, a link pivoted to the inner arm of the said lever, another link pivoted to the first mentioned link, parallel to the inner arm of the lever and pivoted to the framework so as to constitute a parallel link lever mechanism, means for raising and lowering the lever at appropriate times, a toothed quadrant pivoted to the outer arm of the lever in proximity to the finishing mold, said toothed quadrant carrying a fork adapted when swung over to embrace the top of the article being

finished, another toothed quadrant meshing with the first mentioned quadrant and also pivoted on the outer arm of the lever, and a rod connecting the latter quadrant to a portion of the framework in such a way that as the finishing mold opens, the said fork engages the top of the article, substantially as described.

Machine for the manufacture of glass articles. ROBERT FREDERICK HALL. U. S. 1,499,526, July 1, 1924. In a machine for the manuf. of glass articles, the combination of a fixed central column, a framework rotatable about the said central column, a secondary frame adapted to slide vertically with respect to the said framework, in order to adjust the machine for different lengths of parison molds and for different levels of molten glass, means for adjusting the said secondary frame and for retaining it in various vertical positions, a lever of the first order pivoted to the said secondary frame, a sectional parison mold, the sections of which are pivotally carried in fixed relation to the outer arm of the said lever, a counterbalance weight in connection with the inner arm of the said lever, means in connection with the said inner arm of the said lever for lowering and raising the parison mold, link mechanism for opening and closing the said parison mold, an arm in connection with and adapted to operate the said link mechanism, a depending arm pivoted to the rotatable framework of the machine, a tapering slot at the lower end of the said arm, means on said arm engaging the said tapering slot, a horizontal box cam in connection with the said central column, and a follower to the said cam, connected to the said depending arm, substantially as described.

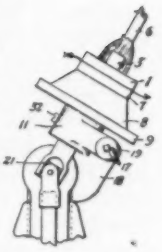


Cracking-off device for sheet glass. JOHN H. MOLLER. U. S. 1,499,393, July 1. The combination with a table on which sheet glass is supported while being scored, of a cracking-off device movable to different positions beneath the table and sheet to elevate the sheet at the score line. The combination with a moving table or conveyor on which the glass sheet is carried while being scored, of a cracking-off device movable to position beneath the score line and comprising means to elevate the sheet.

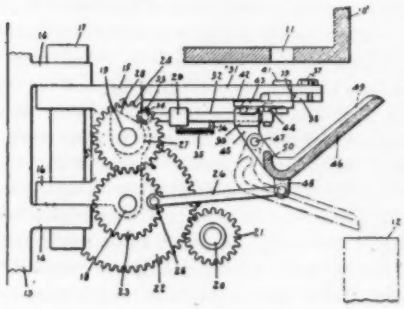


Process for the treatment of silicate compositions. ROBERT L. FRINK. U. S. 1,497,263, June 10. The process of producing a mixed silicate suitable for use in glass manuf. which consists in subjecting a silicate and an alk. metal chloride to the action of heat and a decomposing gas, and treating the resulting reaction mixt. with an active alkaline earth contg. reagent in controlled amounts to partially decompose the same.

Glassworking mechanism. NOBLE W. HARTMAN. U. S. 1,497,332, June 10. The combination with a blow-pipe and a carrying mechanism therefor, of a marvering device comprising a pair of juxtaposed members forming therebetween an aperture of predetd. shape, at least one of said parts being loosely mounted and adapted to be driven by the charge of glass on said blow-pipe during its passage through the said aperture and to roll the said charge of glass into a shape similar to that of the said aperture.



Glass flowing and shearing device. EDWARD MILLER. U. S. 1,497,929, June 17. In a glass flowing and shearing device, the combination with a glass discharging spout, and a glass receiving mold, of shearing means positioned beneath said spout, said shearing means comprising a pair of shearing members, yielding means normally maintaining said shearing members in the open position to permit said glass discharging spout to discharge glass through the same, means for closing said shearing means in opposition to said yielding means for severing the glass passing through said shears, a pivotally supported spoon positioned beneath said shearing means and adapted to receive the severed glass therefrom, means for tilting said spoon to deposit the severed glass into the mold, and means for simultaneously actuating said shearing means and said spoon tilting means in timed relation.



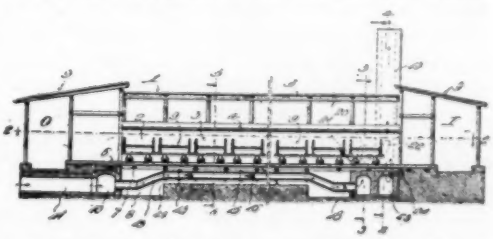
Heavy Clay Products

Bricks from ground clinker. ANON. *South Africa Jour. of Industries*, **6**, 433(1923).—Ground clinker, mixed with $^1/_9$ of its wt. of cement, is being used for making bricks at the municipal gasworks at Würzburg, Germany. By this method, 8 cu. yds. of good building mat. are produced from $^1/_2$ cu. yd. of cement, with an energy-consumption equivalent to about 13 lb. of coal, and are produced at half the cost of ordinary bricks.

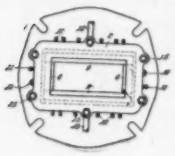
O. P. R. O.

PATENTS

Clay-products drier. ROBERT THOMPSON KYLE. U. S. 1,499,227, June 24. A drier comprising a plurality of tunnels having ware inlets at one end and ware outlets at their other ends, a cross flue under the outlet ends of said tunnels, and a hot air inlet for said cross flue, a second cross flue under the inlet ends of said tunnels, a plurality of heating pipes extending from the first to the second named flue, the space around said pipes being in open communication with said tunnels, a third cross flue adjacent said second flue, the crown of said third flue having openings communicating with the inlet ends of said tunnels, a stack rising from and communicating with said third cross flue, and a fan for drawing air from said second flue and forcing it into said stack.



Die for brick machines. LLOYD W. BROWN. U. S. 1,497,669, June 24. An extrusion die for brick machines, comprising, in combination with a substantially rectangular hollow head, a plurality of complemental die members forming each the top, bottom and sides of the die, the members composing each the top and bottom of the die having their ends overlapping the ends of the members of said sides, and means for adjusting the positions of each of the members of the sides with respect to the adjacent walls of said head.



Refractories

Note on the influence of rapid cooling on the reversible expansion of fireclay. H. S HOULDSWORTH. *Jour. Soc. Glass Tech.*, **7**, 29, 30(1924).—Test pieces of Farnley fire clay were fired to cones 9 and 14–16, held at these respective temps. for 2 hrs., and pieces from each burn were subject to different cooling rates. The methods of cooling included: plunging in cold water, cooling in air, and allowing them to cool slowly in a fur. for 17 hrs. The reversible thermal expansions of the specimens were then determined. In the case of the pieces fired to cone 9 very little difference was noted in the expansions of the pieces cooled at varying rates. In the case of the pieces fired to cone 14, the reversible thermal expansion of the test pieces cooled rapidly differed considerably from that of the slowly cooled specimen. The latter showed a more rapid rate of expansion from 100–200 °C, and from 550–600 than in the other temp. ranges examined, due presumably to the volume changes associated with the alpha-beta cristobalite (or tridymite) and quartz changes, respectively. The rapidly chilled specimens were then reheated in a muffle for 6 hrs. at 950 °C and their reversible thermal expansions determined after cooling. This treatment did not affect the thermal expansions of the specimens. The slowly cooled and rapidly cooled clays on being reheated to cone 12 for 2 hrs. and allowed to cool slowly in a fur. showed considerable change in their expansion-temp. curves. The expansion from 100–200 was now considerably greater than was that previously obtained for the slowly cooled test pieces, while the expansion at 570 due to the alpha-beta quartz inversion was reduced somewhat. The effect on cold crushing strength of varying rates of cooling was detd. It was found that the cold crushing strength was reduced by nearly 30% as a result of rapid cooling, although the actual cold crushing strength is still considerable. J. G. P.

Madagascar graphite. A. D. LUMB. *Bull. Imp. Inst.*, **20**, 61–68(1922).—Production of graphite in Madagascar began in 1907 with an output of 8 T. and increased to 35,000 T. in 1917, but has since fallen off considerably owing to post-war depression. It is of the flake variety and occurs in schists and gneisses in the older cryst. rocks, which extend over two-thirds of the island. About 60% is considered of crucible grade. The mines are worked entirely by natives with European supervision for the larger enterprises. The sepn. of the pure graphite from the gangue is a rather difficult matter principally owing to the presence of mica, which is of nearly the same sp. gr. as graphite and occurs in the same flaky form. In the early stages of the industry the method of treatment was very primitive, the process consisting in washing the mat. in a wooden trough, drying in the sun, panning, and sifting in a hand-sieve. Recent practice makes use either of a dry method, or a wet method, or a combination of the two, and a final concentration by oil flotation. This last treatment ensures a satisfactory separation of the mica and silica from the refined product. The Ceylon and Madagascar deposits are the most important in the world. Although the Ceylon is slightly superior in grade, the Madagascar can be mined much more cheaply and so can be sold at a much lower price. O. P. R. O.

Refractories for coke ovens. W. J. REES. *Coll. Guardian*, **119**, 378(1920).—As a

preliminary to the discussion of properties desirable in bricks for coke ovens, Rees states the general conditions of their use: (1) *Temp.*—The temps. which bricks have to stand are not, in comparison with those met with in other industrial operations, high. In the heating flues the max. temp. under ordinary conditions of coking is not likely to exceed 1350°C. (2) *Load.*—The load is not sufficient to lower the refractoriness of any of the bricks in general use. (Brief reference is made to effect of load on the refractoriness of fire-clay and silica bricks.) (3) *Permeability of Gases.*—The bricks must become fairly gas-tight, and the cement used must also at the temperature of coking produce gas-tight joints. (4) *Resistance to abrasion.*—The bricks must be mechanically strong enough at coking temp. to resist the abrasion of the insertion and withdrawal of the charge and also the abrading action of the hot gases. (5) *Resistance to corrosion.*—This is perhaps the most important factor with which it is necessary to deal; compn. and amt. of impurities present in the coal which are likely to act as corrodants. (Mr. Rees' full report of this appears in *Coll. Guar.*, **117**, 1278(1919).) Taking the Tinsley Park figs., there will be carried into the oven, with each charge of slack and adhering water, approx. 50 lb. of sodium chloride and 20 lb. of sodium sulphate. The salt present will begin to volatilize at 800°C, and in addition to this removal of salt by volatilization, there will be some removed by hydrolysis as steam from the center of the charge comes in contact with the hot coal. In the coke oven the salt vapor, instead of reacting with the surface of the bricks, will penetrate them: there may be some deposition of salt inside the brick, and some of the vapor may pass on to it until it reaches a zone in the brick at which the temp. is high enough for interaction to take place with some rapidity. The joint result of the slower interaction in the cooler portion of the brick and the more rapid action in the hotter zones, will be the formation of a weak spongy mass, which is becoming increasingly more open to the attack of the salt, and which may fall away, or be dragged away, by the moving coal or coke. Another impt. phenomenon in connection with this corrosion, to which attention has been previously drawn by Fearnsides is the very general presence of a layer of hematite in that portion of the brick where disintegration and shearing of the brick are taking place. This is probably due to the formation and volatilization of ferric chloride by the action of the salt vapor on iron oxide, present either in the coal or more probably in the bricks. This vapor will penetrate the porous bricks until it reaches a zone in the brick to which oxygen, containing gases from the combustion flues, penetrate, and it will then be decomposed with the formation of hematite which will be deposited. Besides the disruption due simply to chem. attack, disruption may take place due to the fact that the corroded part will have a different coeff. of expansion to the remainder of the brick, and with the repeated heating and cooling of the oven wall, the differential expansion and contraction may cause a falling away of the corroded portion of the brick. An example of the corrosive action of salt came under the writer's notice in connection with expts. on the effect of heat on mixt. contg. salt, limestone and sand. At temps. of 1350° to 1400°C, the clay lining of the contg. vessel was very rapidly corroded. The clay was replaced by a silica lining, and the corrosion was very considerably reduced. The exptl. evidence indicates that salt corrosion is likely to be much more severe on fire-clay bricks than on either alumina or silica bricks. American practice has been largely in the direction of the use of silica bricks; there are, perhaps, factors in connection with the size, construction and general coking practice which have minimized the difficulties of their use. In making silica bricks it is necessary to add to the crushed silica rock some mat. which will, at high temperature, act as a bond; the mat. almost invariably used is lime. This addn. of lime reduces the refractoriness of the silica, and the propn. which can be used, depends on the size of the fragments of quartz, and on the impurities present in the silica rock. The size and grading of the fragments of silica for coke oven bricks, and the compn. of the matrix are of paramount importance. Le Chatelier, in France, carried on exptl.

work, which definitely indicated that by substituting for ordinary fine material used in making brick, an impalpable powder obtained by grinding the raw silica rock in a tube-mill, a brick of distinctly superior physical properties could be produced. Test bricks were made, which were burned at approx. 1500°C, and the foll. results were obtained from them in standard tests:

Compn. of mixt.	Linear expansion per c.	Density		Crushing strength in kilogs. per sq. cm.		
				Cold		
		Apparent	Real	Dried	Burnt	At 1600°C
75 crude quartzite 25 impalpable quartzite 2 lime	5.2	1.63	2.35	15	165	30
75 crude quartzite 25 fine quartzite 2 lime	...	....	2.33	10	60	8
25 crude quartzite 75 impalpable quartzite 2 lime	3.9	1.36	2.35	9	135	10
25 crude quartzite 75 impalpable quartzite 2 lime	...	....	2.33	6	52	3

The superiority of the brick contg. 25% of the impalpable quartzite powder is very apparent. This exptl. work has been amplified in this country (England), and it has been proved on the large scale that by using a silica rock which, on crushing, gives angular fragments, by suitably grading these crushed fragments and by mixing them with a definite propn. of impalpable silica powder (with which a bonding mat. has been mixed) bricks can be made which have a very satisfactory texture, and in which the after-expansion during use is small. The foll. is an anal. of a silica brick which has a satisfactory phys. constitution, but it is obvious from the foregoing that, within limits the texture and mineralogical constitution of the brick are of more importance than its chem. compn.:

	Per cent		Per cent
SiO_2	95.16	MgO	0.15
Al_2O_3	1.29	K_2O	0.51
Fe_2O_3	0.78	Na_2O	0.24
TiO_2	0.15	Total	100.16
CaO	1.88		

The condy. from heat of the refractory mat. used for the coke oven is a factor which needs some consideration. Measurements and experience in American coke oven practice indicate that at coking temps., the condy. of a good silica brick is decidedly greater than that of a fire clay or semi-silica brick, which should be another point in favor of the use of silica brick in coke oven construction. (This paper was given before the Midland Section of the Coke Oven Managers' Assn., with further discussion, page 454, *Coll. Guardian.*) O. P. R. O.

Refractory materials. J. W. MELLOR. *Coll. Guardian*, **117**, 479, 537, 719, 775 (1919).—Synopses of a series of lectures given by Dr. Mellor before the Soc. of Chem. Indus. dealing with the development and problems peculiar to the refrac. mats. problem. O. P. R. O.

Fire clay and silica brick as gas-house refractories. A. F. GREAVES-WALKER. *Gas Age-Record*, **53**, 567–70(1924).—U. S. resources of refractory fire clays are given; Georgia surpasses all other states in quantity of reserves. Mfg. methods for fire-clay brick are outlined. Requirements for gas house refractories are listed and most salient features pointed out. The characteristics of silica brick are listed and discussed from the viewpoint of gas-house refractories. H. G. B. (*C. A.*)

Tests on clays for making zinc retorts. K. ENDELL AND W. STEGER. *Metall u. Erz*, **20**, 321–31(1923).—Tests on a no. of German, Belgian, and American clays have been carried out to det. their suitability for making zinc retorts. Detns. were made of the chem. and rational compn., the shrinkage on drying and the softening point of the raw clay, the linear shrinkage and porosity of the clay after firing to 1000°, 1100°, 1200°, 1300°, and 1450°, and the softening point of a mixt. of equal parts of grog and clay under load at high temps. The plastic ball clays tested contained over 95% of clay substance and the lean clays between 50 and 75%, but the plasticity and shrinkage on drying were not propl. to the amt. of clay substance present. The ball clays, with the exception of the Amer., attained their max. and linear contraction at 1100°, while the leaner clays continued to shrink slowly with further rise of temp. The fusion point lay between cones 28 and 34 (1630–1750°) and was independent of the content of clay substance. The softening point of mixts. of clay and grog under load was higher the higher the SiO_2 content of the grog. Six retort mixts. after firing at 1000° showed values for the tensile strength between 9 and 66 kg. per sq. cm., the latter being found in the Amer. mixt. owing to its high content of Fe_2O_3 (3.88%) and TiO_2 (1.48%). The shrinkage on firing, porosity, and fusion point of all the mixts. were practically the same, but the German (Silesian) mixt. softened under load about 100° below the others. Clay mixts. contg. 60% to 80% of SiC softened about 100° higher than the grog mixts., but had the same porosity. J. S. C. I. (*C. A.*)

Determination of thermal conductivity of refractories. M. D. HERSEY AND E. W. BUTZLER. *J. Wash. Acad. Sci.*, **14**, 147–51(1924).—See *C. A.*, **18**, 889.

C. H. K. (*C. A.*)

Some Italian magnesite deposits. G. CASTELLI. *Rass. min. met. chim.*, **60**, 5–8 (1924).—Several $MgCO_3$ deposits of special value are described stratigraphically. *Castiglioncello.* The product, which is hard and white, analyzed in %: $MgCO_3$ 88.72, SiO_2 3.40, Fe_2O_3 1.80, CaO 3.15, MgO 42.45, H_2O and loss of ignition 49.20%. Large amts. valuable in metallurgy and for the prepn. of Mg salts are available. *Monterufoli.* Because of impurities the material is useful only after special sorting. Av. compn.: $MgCO_3$ 86.02, $CaCO_3$ 9.60, Fe_2O_3 + Al_2O_3 2.71, insol. in HCl 1.67%. *Island of Elba.* Av. compn.: $MgCO_3$ 84.50, $CaCO_3$ 1.00, SiO_2 11.00, Al_2O_3 0.50, Fe_2O_3 0.90, H_2O 2.10%. *Querceto.* These are the most important deposits in Italy. The best material has the av. compn.: $MgCO_3$ 97.19, $CaCO_3$ 0.93, SiO_2 1.12, Fe_2O_3 0.63, Al_2O_3 0.13%, and is used for chem. products. A second grade, contg. 96.06% $MgCO_3$, is used for cement; and a third grade contg. 95.85% $MgCO_3$ for refractory basic brick for furnaces.

C. C. D. (*C. A.*)

Whiteware

Five thousand pieces of sanitary ware a week. ANON. *Cer. Ind.*, **3** [1], 39(1924).—(The Thos. Maddock's Sons Co., Trenton, N. J.) Domestic and imported raw mats. are used. French amorphous flint pebbles are imported and calcined in a small updraft wood fired kiln having a capacity of 18 tons of pebbles. The kiln is filled with wood and pebbles in alternate layers. The calcined pebbles are crushed in a chaser mill and dry ball milled to pass 200-mesh. Batch cars are used in weighing up the batches which are blunged in two five-ton blungers for 2 hrs. The slip is discharged into the raw agitator from which it is pumped over a double lawn of 100- and 120-mesh

respectively. After passing over the magnetic separators, the slip passes into two finished raw slip agitators from which it is pumped to the four filter presses at 110 lbs. pressure, 32 mins. being required to fill each press. The 4 presses are emptied and refilled in $1^1/_2$ hrs. After being filter pressed the clay body is either sent to the pug mills to be pugged for use in making ware by the pressing process or sent to mixing tubs to be made into casting slip. The four mixing tubs each have a capacity of 5000 lbs. of casting slip. Thirty-five tons of casting slip are prepd. daily. The salts are added in the mixing tubs. The slip is kept in storage agitators from which it is pumped to the casting rooms. A slip wt. of 32 ozs. to the pint is maintained. A total of 5000 pcs. of ware a week is produced by 91 casters and 53 pressers. Two hrs. are required to cast a piece and two casts per day are made with the same mold. The ware is dried on steam heated open floors for 10 days after which it is finished and carried on an overhead conveyor to the green room and kept at a temp. of 80°F until ready for the kiln. Grog ground to from 10- to 30-mesh constitutes 50% of the sagger body mix. The batch is aged 6 days before being pugged. A gang of 3 men make 250 stand. saggers per day on one mach. About 40 larger hand made saggers are made per man per day. The saggers average 8 fires. An elec. driven movable vertical pug mill is mounted on a track with three soaking pits for sagger batches on either side. There are 21 down draft coal fired periodic kilns each having a capacity of 400 pcs. of ware. The ware is bisque fired in saggers to cone 9 in 30 hrs. The temp. is measured with pyrometric cones. A fritted transparent lead glaze is used. The frit is fired in saggers in the bisque kiln, ground in a chaser mill and ball milled 18 hrs. with the other glaze ingredients. The glaze is sieved through a 130-mesh silk lawn and passed over a magnetic separator. The ware is dipped one day and placed in the kilns the next. The glost firing is done at cone 8 in 30 hrs. A bonus system is very instrumental in reducing the labor turnover and increasing the quality and output of the ware. P. D. H.

Some facts about ball clays. FRED S. BELL. *Cer. Ind.*, **3** [1], 27(1924).—Clays should be produced in stand. selections and not mixed at the mines. Clays from different strata but from the same deposit when fired to cone 7 vary from 0 to 9% absorption, whereas the color varies from buff, through grayish white to white. The producer should know the charact. of each stratum of clay and be reasonably familiar with the requirements of each line of ceram. product in which the clay is used. The most satisfactory way for testing ball clays is to substitute the clays in question in actual body mixts. and fire samples in different parts of the kiln in order to obtain the max. variation in temp. treatment. Inasmuch as it is difficult to obtain uniform sagger clay, the use of a certain amount of stand. ball clay is justified and thus permits the use of more tender refrac. clays. The overfiring temp. of a refrac. clay is quite as important to know as the fusion temp. A graph is shown illustrating the increase in strength of blunged clays over clays that are soaked down. Weathering is beneficial only when the entire mass of clay is kept soaked with water. P. D. H.

The properties of technical porcelains of the Royal Berlin Porcelain Factory. R. RIEKE. *Z. angew. Chem.*, **37**, 190(1924); cf. *C. A.*, **18**, 157.—Detns. made during the last few yrs. may be summarized as follows, comparing Royal Berlin (*a*) with 7 other technical porcelains (*b*). Tensile strength (*a*) 320, (*b*) 161–265 kg. sq. cm.; ball-test compressive strength (*a*) 1376, (*b*) 674–1384 kg.; transverse strength (*a*) 855, (*b*) 588–777 kg. sq. cm.; impact transverse strength (*a*) 1.99, (*b*) 1.75–1.95 cm. kg. sq. cm. Ball-test compressive strength was detd. on plates 10 cm. in diam. and 1 cm. thick, between 2 steel balls of 31.7 mm. diam. Transverse strength was detd. on cylindrical pieces 16 mm. in diam. and 120 mm. long. Impact strength was detd. on a pendulum type of app. built by Schopper in Leipzig, the test pieces being 16 mm. in diam. and 12 cm. long. Soly. and appearance under the microscope are briefly discussed. C. H. K. (*C. A.*)

PATENTS

Machine for making crucibles. WILLIAM G. MOLAND. U. S. 1,497,190, June 10. In a machine for forming crucibles and the like having a bilged shape, the combination of a separable mold of fixed circumferential dimensions, a collapsible bilge shaped core mechanically associated therewith, and means for forcing a measured quantity of material into the space between the core and the mold and for thereafter compressing the same within said space to thereby form the crucible.

Machine for forming earthenware tanks. WILLIAM G. MOLAND. U. S. 1,497,191, June 10. In a machine for forming earthenware tanks, a mold, a plunger head slidably mounted therein, controllable means for applying pressure to said plunger head, a core member adapted to be supported within the mold, said core member being of such shape and dimensions with respect to the mold as to provide a space between said core member and said mold in which the tank is formed, and means for holding said core member in fixed relationship with respect to the tank during the forming operation and for thereafter withdrawing the core with respect to the mold.

Equipment and Apparatus

Practical dissertation on pebble mills. EDWARD W. LAWLOR. *Cer. Ind.*, **2** [6], 369–70(1924).—In order to eliminate iron contamination from man hole covers on ball mills, it is suggested to line the cover with a block of rubber instead of silex. This would also insure a tight fit. It costs, in material and labor, about $300 to line a 6′ x 8′ mill with silex. The inside diameter of the mill is reduced 6″. The mill is out of operation about one week. The surplus lime-carrying cement must be removed by running a while after relining. A $^5/_8$″ rubber lining (*India Rubber World*, Aug. 1, 1923, and Nov. 1, 1923) has been run in an ore mill loaded with iron balls for 9 mos. and was still in good condition, whereas a silex lining would have worn out in 6 to 8 mos. After 3 mos. service running 24 hrs. per day and after having ground at least 1000 T. of ore, no signs of wear were apparent. It would take 2 men 5 hrs. to replace an entire rubber lining. The rubber is made in man hole size strips. Rubber lining increases the capacity of the mill and reduces the cost of grinding. Any small particles of rubber passing through the sieve would be readily burned out of the ware. Irregular shaped pebbles grind better than round ones as the voids are reduced. The mill should be half full of pebbles and the charge about 23% of the total cubic capacity or 1 cu. ft. of pebbles to $^1/_2$ cu. ft. of mat. P. D. H.

Heat transfer in furnaces as caused by radiation of gases. ANON. *Fuels and Fur.*, **2**, 675–8(1924).—A presentation and discussion of mat. from *Bull.* No. 55 of the Heat Economy Bureau of the German Iron and Steel Institute (Alfred Schack), deals with heat transfer by radiation from clear gases. Diatomic gases radiate and absorb but an infinitesimal amt. of heat, while the spectra of CO_2 and H_2O vapor (both triatomic) show broad absorption (and radiation) bands, most of which lie in the infra red, or invisible portion of the spectrum. *I. e.*, products of combustion contg. CO_2 and H_2O vapor can radiate considerable quantities of heat, although they are practically non-luminous, and scarcely visible. Equations and curves are presented and tables of computations given for radiation in cal. per sq. m. per hr. of infinitely thick layers of CO_2 and H_2O vapor at different temperatures. If the gases are flame filled, incandescent particles of C float in the gas stream and increase the radiation. It is shown that low velocities of flow, and time for the gases to radiate their heat are needed at high temps., while at lower temperatures high velocities of flow are desirable, in order to increase the heat transfer by convection. A stagnant layer of products of combustion in the roof is useful because the gases absorb ht. and protect the roof from too intense a radiation. W. E. R.

Kilns, Furnaces, Fuels and Combustion

Lighting oil and gas burners. M. H. MAWHINNEY. *Fuels and Fur.*, **2**, 687–91 (1924).—Practical pointers on the lighting of cold fur. W. E. R.

Combustion devices for liquid fuel. W. TRINKS. *Fuels and Fur.*, **2**, 21–4, 135–8, 255–8, 349–52(1924).—Describes oil burners under classification of 3 types: Vaporization, atomization and a combination of vaporization and atomization. Indus. application is limited chiefly to atomizing burners. The paper discusses methods for obtaining proper mixt. of atomized liquid fuel and air in furnaces, with conclusions summarized in tabular form:

Methd of atomization	Velocity of oil ft./sec.	Velocity of atomizing air ft./sec.	Lbs. of atomizing air per lb. of oil	Weight of momentous of oil and atomizing air	Weight of air to be induced	Velocity of resulting mixture	Pressure against which air can be induced inches of water
Mechanical oil 150 lbs. per sq. in.....	165	0	0	166	14	11	0
High press. air atomization 100 lbs./sq. in.	...	1600	1.12	1792	12.88	120	1.00[1]
Low press. air atomization 2 lbs./sq. in..	...	490	4.62	2270	9.38	151	1.70
Fan blast atomization. Air at 4 oz. pressure.....	...	139	9.50	1320	4.50	88	0.11

[1] The high pressure burner can induce against a higher pressure if more than the minimum quantity of air necessary for atomization is used. W. E. R.

Industrial heating furnaces. E. F. COLLINS. *Chem. Met. Eng.*, **30**, 936–41 (1924).—Lists the characteristics of elec. heat, and the different types of fur. with especial emphasis on the metallic resistor type. Photographs are given of different installations, with some performance records. M. E. M.

Metallic resistor furnaces. E. F. COLLINS. *Chem. Met. Eng.*, **30**, 981–5(1924).—Discusses the laws, chem., phys., and economic, governing the use of this equipment. M. E. M.

Electric furnace developments. FRANK HODSON. *Iron Coal Trades Rev.*, **108**, 596(1924).—A review. J. F. B. (*C. A.*)

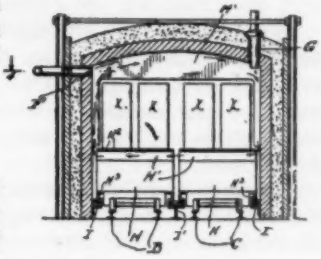
The electric furnace in the porcelain industry. ARTURO PAOLONI. *J. four elec.*, **33**, 70(1924).—This is a resistor furnace which can be readily maintained at the prescribed temp. (1400–1500°) for a porcelain kiln. The resistor material consists of artificial graphite (99% C). The heat reflecting walls are constructed of recrystd. carborundum. Two types of furnaces have been tried out, an intermittent type with a single chamber, and a "continuous" or tunnel type with 12 chambers in series. C. G. F. (*C. A.*)

BOOK

TRINKS, W.: **Industrial Furnaces.** Vol. I. New York: John Wiley & Sons. 319 pp. 22s. 6d. (*C. A.*)

PATENT

Twin-tunnel kiln and method of operating the same. CONRAD DRESSLER. U. S. 1,499,354, July 1. The method of regulating the rate of heat transfer from the hotter ware to the colder ware in the end portion of a twin tunnel kiln, which consists in setting up a forced circulation of the kiln atmosphere in said portion of the kiln along paths looped about the kiln axis.



Geology

Pottery clay (Australia). ANON. *Bull. Imp. Inst.*, **21,** 321(1923).—White clay from Bendigo, Victoria, was tested by the Imp. Inst. 1921, on its suitability for the manuf. of porcelain and refrac. bricks: the results indicated that the clay, after washing to remove gritty matter, was suitable for the manuf. of white permeable pottery, which could be glazed to yield a fine white earthenware, and could also be used in admixt. with "grog" for production of second-grade refrac. brick. In 1922 further trials were carried out, in conjunction with felspathic and siliceous materials available for the purpose. This clay was grayish in color, plastic and practically free from grit, and superior to material examined in 1921. From the considerable differences in the compn. of this clay and previous samples, it is probable that the clay varies in different parts of the deposit. While results of these tests showed the clay to be quite suitable for manuf. of stoneware or semi-porcelain, large scale trials would be advisable to det. the working properties of the clay under indus. conditions. Mfg. operations would necessitate careful chem. control. O. P. R. O.

Bauxite (Gold coast). ANON. *Geol. Surv. Rept. of Gold Coast,* **1921.**—Further discoveries of bauxite deposits have been made in the Colony. The ore varies in quality, some of high grade while much is highly ferriferous. An interesting feature of these bauxite deposits is that in some cases they carry both gold and silver in appreciable quantities. It is suggested in the Rept. that the gold and silver might be worth recovery from the insol. residues which would result from the treatment of the bauxite by the Bayre process. O. P. R. O.

Bauxite (India). K. P. SINOR. *Bull.* **3** (1923) (Geol. Dept. of Rewa Ste).—Bauxite of high grade is found in large quantities on the Amarkantak plateau, and in the hills north of Nerbudda River. Sinor describes these deposits with special reference to the possibilities of establishing an aluminium-producing industry in the State. Picked specimens of this bauxite contained from 62 to 66% of alumina, the general quality ranging from 51 to 57%. Bauxite of lower grade occurs in large quantities at many places in the Ste. O. P. R. O.

Mineral pigments (Australia). ANON. *Bull. Imp. Inst.*, **20,** 244(1922).—Valuable deposits of oxides and ochers have been found, principally in the neighborhood of Cape Flattery. Samples of quartz sand-washed from these pigment deposits in the course of refining have been investigated at the Imp. Inst., and found to be suitable for the manuf. of glass, for such purposes as the production of pale-tinted bottles. (*Chem. Trade Jour.*, 694(1921).) O. P. R. O.

Fluorspar deposits of Kentucky. LOUIS W. CURRIER. *Ky. Geol. Surv.*, **13,** 6(1923).—Describes the origin, occurrence, association, mining, milling and uses of Kentucky fluorspar. C. E. B.

Chemistry and Physics

Borax from colemanite. BURTON G. WOOD. *Chem. Met. Eng.*, **30,** 976–8(1924).—The process by which borax is obtained from colemanite is described in detail. M. E. M.

Viscosity. The British Engineering Standards Association (28 Victoria St., London, S. W. 1) has issued Publication No. 188—1923 "British Standard Method for Determination of Viscosity in Absolute Units." H. H. S.

BOOK

FREUNDLICH, DR. HERBERT: **Kapillarchemie: Eine Darstellung der Chemie der Kolloide und Verwandter Gebete.** Third edition pp. xvi — 1225. Leipzig: Akademische Verlags-ges., 1923.—Deals with colloid chem. in relation to surface tension, adsorption, electrical surface effects, kinetics of new phases, Brownian movement, sols (lyophobe and lyophile), gels, clouds, smokes, and systems in which the continuous phase is solid. H. H. S.

Preparation of alumina from metallic nitrates. ANON. *Oil and Color Trade Jour.*, **65,** 1744(1924); (Ger. 339,983, Goldschmidt, Christiania).—Aluminium and other nitrates are partially decomposed by ht., so as to form a mixt. of hydrated alumina and undecomposed nitrates of the other metals, the latter being removed by lixiviation. The nitrous fumes evolved are converted into nitric acid, which is utilized for the dissociation of fresh quantities of the raw materials. The recovered nitrates of lime, potash, soda, etc., can be worked up into a mixed fertilizer, or treated for the sepn. of the constituent nitrates or the production of nitric acid by known methods. O. P. R. O.

Geology

Some methods for heavy mineral investigations. R. D. REED. *Econ. Geol.*, **19** [4], 320–37(1924).—The paper discusses methods adapted to correlations by the study of heavy mineral residues. C. W. O.

Manufacture of potash and other salts from leucite. J. W. HINCHLEY. *J. Soc. Chem. Ind.*, **43,** 158–69(1924).—The fact that the whole of the world's supply of potash is still obtained from practically one district is a matter of concern to other nations. The most hopeful source of supply is in the minerals of igneous rocks, and of these leucite, which occurs along the line of the Italian volcanoes, is the most attractive. Leucite, $K_2O.Al_2O_3.4SiO_2$ in a state of purity contains 21.5% K_2O, 23.5% Al_2O_3, 55.0% SiO_2. The natural mineral contains less potash through replacement by MgO and Na_2O, but in some places, notably Rocca Monfina, fine leucite occurs in large quantities, computed by H. S. Washington to contain 1008 metric T. of K_2O. Voelcker finds that powdered leucite has the same manure value as soluble manures of the same potash content. The Rocca Monfina industry is being developed by Baron Blanc, who found that if acid be continually circulated through grandular leucite a soln. was obtained in which no gelatinous silica occurred to make the sepn. of liquid and solid difficult. With sulphuric acid, potash alum is formed, and the residual silica is added to caustic to form sodium silicate. The yield of alum and sod. silicate is 80%. As the market for alum is not large, Blanc also treats leucite with HCl which presents greater chem. engineering difficulties on account of the volatility and greater corrosive action of HCl. The plant must be completely closed, with a vent connected to a scrubbing tower for removal of fumes. The product KCl and Al_2Cl_6 are passed into a cooling app. where KCl crystallizes out. The liquor is treated with HCl gas and hydrated aluminum chloride crystals are pptd. These heated to 280°C yield al. hydroxide and HCl. The yield is 93%. One T. of leucite requires 618.3 kg. of HCl gas or 197.6 kg. of H_2SO_4. Taking factory operations, handling 36 T. of leucite per day, 5 T. of HCl would be required. The cost of fuel would be $0.70 per T. of leucite treated, and the products would amt. to $10^1/_4$ T. KCl, 8 T. alumina, and 9 T. silica. Other processes than Blanc's are: Haege's process for making a phospho-potash fertilizer, an acid process using HNO_3, an elec. fur. process for pot. carb. and alumina, and an autoclave process for producing caustic potash from leucite and lime; the last two due to Jourdain. H. H. S.

Systematizing combustion practice for educational purposes. C. BLACHER-RIGA. *Feuerungstechnik*, **12** [11], 81(1924).—Tabulates for comparative purposes the principle characteristics accompanied by simple line sketches of (1) Boiler fur., (2) Gas generators. These tables cover in a very compact and comprehensive way the various methods used in practice and show clearly the general principles involved. F. A. W.

Measurement of the surface tension of glass. AD. LECRENIER. *Bull. soc. chim. Belg.*, **33**, 119–22(1924).—The drop wt. method was used, results being calcd. from Glugialmo's formula $\alpha = (p/2\pi r)(1 + r/R)$, where α is the surface tension in mg./mm., p the wt. of the drop in mg., r the radius of the dropping orifice in mm., R the radius of curvature of the tip of the drop. The app. consisted of a Pt crucible with an orifice in its bottom (r = 1.928 mm.) suspended in a vertical tubular elec. fur., a thermocouple being placed near the dropping tip. To det. p a large number of drops were collected by dropping into hot oil. R was detd. by permitting a drop to form but removing the crucible vertically from the fur. just before the drop fell, the drop being obtained suspended by a long glass thread; thus no distortion of the tip was introduced. A number of observations were made at each temp., the max. deviation being approx. 6%. For an ordinary soda glass the values of α were 41.58 (1025°), 41.42 (1125°), and 41.23 (1225°), while flint glass gave 39.66 (1025°), 39.16 (1125°), and 38.97 (1225°).

W. B. P. (*C. A.*)

Specific heats of products of combustion from gas furnaces. L. E. BIEMILLER. *Gas Age-Record*, **53**, 423–4(1924).—The sp. heats of CO_2, SO_2, H_2O vapor, N_2, O_2, and CO are recalcd. from the data of Lewis and Randall (*C. A.*, **6**, 3353) into units of B. t. u. per cu. ft. (at 60°F and 30 in. Hg) per °F for the temp. interval 60°F to t°F to make them directly applicable to industrial gas calcns. Curves are given.

H. G. B. (*C. A.*)

Production of pure alumina from clay. HARALD PEDERSEN. *Tids. kemi Bergvesen*, **3**, 161–4, 175–8(1923); **4**, 11–7(1924); *Teknisk Ukeblad*, **42**, 75–7, 83–6(1924).—A full report of a radically new process for the production of Al_2O_3 for Al manuf. The raw material was a common Norwegian clay contg. Al_2O_3 16%, Fe_2O_3 8%, CaO 2%, MgO 1%, Na_2O 2.5%, K_2O 3.5%, and SiO_2 55%. As mined it contained 30% H_2O but was easily air-dried to 5–10% H_2O. A usable clay should contain not more than 4% of CaO and as much Al_2O_3 and K_2O as possible. The air-dried clay is kneaded and mixed with cold H_2SO_4 (chamber-acid). An excess of clay is best used to obtain a high yield of the acid and a better decompn. of the compds. of K_2O and Al_2O_3 than of the Fe compds. To 1 ton of clay 1.2 ton of the acid was theoretically required, whereas 0.7 ton was found to give the best economy. The reaction mixt. was allowed to remain quiet for 12 hrs. and then was heated to 150–200°. The SiO_2 is thus converted to an amorphous, easily filterable state and part of the $FeSO_4$ is converted to basic ferric sulfate, the liberated H_2SO_4 attacking the excess clay and forming additional amts. of Al and K sulfates. The mass was then leached counter-currently, the temp. being kept at about 80°. At this point considerable amts. of Fe are sepd. as basic ferric sulfate and an extra amt. of Al and K is dissolved from the excess of clay. The resulting residue contained 8% of total H_2SO_4 calcd. to dryness. The liquor had a sp. gr. of about 1.35 and contained 80 g. Al_2O_3 and 20 g. K_2O per l. The Fe content was about 16% of the Al_2O_3, whereas in the original clay the ratio was about 40–100%. The liquor was cooled to 15° whereby $^1/_3$ of the Al_2O_3 was pptd. as K alum. The rest of Al_2O_3 was pptd. by addn. of solid K_2SO_4 under agitation at a relatively low temp. From 1 cu. m. liquor 700 kg. of raw alum with 0.1% Fe was obtained. This salt was dissolved in hot water and recrystd., yielding an alum with only 0.005–6% Fe. The water of crystn. was removed by heating in a rotary drum with producer gas. Drying in Fe pans was not successful owing to the viscosity and low heat condy. of the fused salt and its action on the iron. No

H_2SO_4 was expelled during the drying. The decompn. of the alum offered great technical difficulties, and was finally accomplished by heating directly with producer gas in a vertical shaft furnace charged at the top and discharged at the bottom. The gases contained 8 vol. % of SO_2. The decompn. product corresponded very closely to the formula $Al_2O_3.K_2SO_4$. It was leached hot with a soln. of K_2SO_4 satd. cold, the dissolved K_2SO_4 being pptd. by cooling. Per ton of Al_2O_3 produced something over 400 kg. of very pure K_2SO_4 was obtained. The residual Al_2O_3 from the filters contained about 50% H_2O which was easily removed by heating to 400–500°. The consumptions of coal and H_2SO_4 per ton pure Al_2O_3 were as follows: Heating the reaction mass 375 kg., drying the alum 800 kg., decompn. of the alum 600 kg., drying the oxide 200 kg., heating various liquids 316 kg., total 2.291 kg. Loss of H_2SO_4 by decompn. 36 kg., in the clay residue 1260 kg., in the alum 3221 kg., in the mother liquor 516 kg., total 5033 kg.; recovered by decompn. of the alum and absorption 2,855 kg., resulting net consumption 2,178 kg. When the market value of the recovered K_2SO_4 is taken into account a smaller net cost per ton of Al_2O_3 produced from clay by this procedure is obtained, compared with Al_2O_3 produced from bauxite by the Bayer process. The use of *labradorite* was tried in this process, but although the Al content of this material (about 30%) is much higher than in clay the latter is more favorable, owing to the valuable K_2O content. Labradorite contains no K_2O but much H_2SO_4-consuming CaO.

C. H. A. S. (*C. A.*)

General

Spontaneous combustion of coal. J. I. GRAHAM. *J. Soc. Chem. Ind.*, **43**, 79T–87T(1924).—Two theories regarding spont. combustion have been held, one that it is due to pyrites (FeS_2) oxidizing to $FeSO_4$; the other that it is the result of oxidation at ordinary temp. of org. subs. in coal. The pyrites theory does not explain all cases nor is a high rate of oxidn. of coal the only factor. A most important property is that of friability, the prodn. of fine dust being a necessary factor. With regard to the constituents of coal, G.'s result on oxidn. of durain, clarain, and vitrain, agree with those of Wheeler and Tideswell, but differ markedly in respect to fusain. G. finds that fusain from different sources shows very slight absorpn. and similar results have been found more recently by T. and W. H. H. S.

BOOK

DUNN, J. T., D.Sc.: **Pulverised and Colloidal Fuel.** Pp. 197. London: E. Benn, Ltd. 1924. Price, 25s. H. H. S.

BOOK REVIEW

A Preliminary Report of the Clays of Florida (Exclusive of Fullers' Earth). BY OLIN G. BELL, 1924. 207 pages. From the Fifteenth Annual Report of the Florida State Geological Survey, Tallahassee, Florida.

This report considers only the known clay deposits within reach of transportation and without excessive overburden. The general geology, classification, mineralogy, chemical and physical properties, and uses of the clays are briefly discussed. Complete footnote references are made to other writers. The clays were tested by Mr. Bell in the clay testing laboratory of Dr. H. Ries at Cornell University.

The contents of the report are briefly reviewed by chapters.

Chapter I. General Geology of Clays. The term clay is defined, and the origin of clays and the various geologic types of clay deposits are given.

Chapter II. Classification of Clays. The classification of Ries is given based primarily on the geological occurrence and secondarily on the firing qualities of clays.

The classification of Grout and Soper is given based on physical properties with refractoriness as the basis of subdivision. Reference is made to Parmelee's classification which is based on the uses of clays according to their physical properties.

Chapter III. Mineralogy and Chemical Properties of Clays. The various minerals found in unfired clays are noted together with the abundance, physical properties and pyrochemical behavior of the respective minerals. The minerals found in fired clays are discussed briefly. The relative merits of ultimate versus rational chemical analysis are given. Included is the information obtainable from an ultimate chemical analysis as listed by Ries. The chemical effect of the various constituents in clays on the firing behavior of the clay is also given.

Chapter IV.—Physical Properties of Clays.—The more important physical properties are treated. The nature of the vitrification process, as discussed by Orton, is given. The Seger cone numbers, as commonly used for guidance in the firing of the different classes of ware listed, are indicated in a table. A chart is also given showing the important firing range temperatures of various clay products.

Chapter V.—Tests Made Upon Clays.—The methods used in the determination of the physical properties, both in the unfired and fired state, are given.

Chapter VI.—Kinds of Clays and Their Uses.—The physical properties of the different kinds of clays are noted together with their chief use. The uses of raw and fired clay as listed by Ries are also given.

Chapter VII.—Geology of the Clays of Florida.—The stratigraphy of the geologic formations in Florida is thoroughly covered in a table. The physical nature, location, extent and thickness of the various formations are noted together with the geologic age, occurrence and distribution of the clays. The conditions of sedimentation and sources of material are also discussed.

Chapter VIII.—Distribution and Description of Deposits by Counties.—The various clay deposits are described with reference to their extent, properties and uses. The more important physical properties of the unfired clays and of the clays fired to different temperatures have been determined and the results listed. The various uses to which each clay is suited are also given. A number of views of plants and clay pits are shown. A map of Florida shows the location of ceramic plants, kaolin mines, Fuller's earth mines, points where common clays were tested and sedimentary kaolin occurrences.

Chapter IX.—Sedimentary Kaolin.—The terminology of the clay is discussed and its general distribution given. The deposits are described and their geologic age discussed. Various theories are given for their origin. The history of their development is noted together with their uses, the names of companies working the deposits and the methods of mining employed. Samples from the different producers were tested and the results obtained on the unfired specimens, as well as on those fired to different temperatures are noted. Results of chemical and mineralogical analyses are given. Distribution of the deposits is given by counties. Some plant views are shown.

Chapter X.—Development and Possibilities of the Clay Industry in Florida.—A history of the development of the industry is given and the present status described. The future possibilities based on the local potential demand are noted.

Chapter XI.—Methods of Prospecting for Clays.—A procedure is recommended for making the preliminary tests and for determining the extent and uniformity of the deposit.

Appendix A.—Statistics of Production of Brick (1899 to 1922).

Appendix B.—Fusion Points of Seger Cones (including chemical composition).

Appendix C.—Directory of Florida Clay Workers (exclusive of Fuller's earth).

Appendix D.—Bibliography of Florida Clays.

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EDITORIAL

THIRTY YEARS OF COLLEGIATE TRAINING IN CERAMIC ENGINEERING

It was in September, 1894, thirty years ago, that Professor Edward Orton, Jr. first sat before a class in "ceramic engineering." This was a unique event; the beginning of a system which in time was to be valued by the ceramic plant owners, although then little appreciated. That young professor had no way of visioning what would be accomplished in thirty years; sufficient was the faith in the opportunities for which he and his "boys" were preparing. Their faith has been justified.

When the first class was called to order, Professor Orton had already contributed largely to the advance which has since been made in ceramic technology. A cursory review of the thirty years which have followed will encourage and enthuse for the larger accomplishments yet to be realized. Such a review will be worth making, and as surely as it is made so surely will no small debt of gratitude be felt and no few words of appreciation be spoken of the foresightedness and ability to accomplish which made possible the meeting of that first class in ceramic engineering in 1894.

Ten collegiate institutions of learning in this country, and one in Canada, now have similar courses in ceramic engineering. Georgia, Penn State and North Carolina have established courses within the past year. At all

of these institutions the students are made acquainted with those fundamental sciences which are basic in ceramic engineering. They are trained in the use of facts in the solving of ceramic problems. The pupils learn the methods whereby these fundamental data are obtained, where they are recorded, and the engineering use which they serve.

Of greatest value is the training received by the students in the use of data. The fundamental facts may be only hazily remembered, but the methods of using them in the solving of problems and in the constructing of things according to the fundamental laws applying, is permanently acquired and is the real essence of the training received. Facts regarding gases, combustion, drafts, flue systems, etc., are essential, but of more importance is ability to design efficient kilns and furnaces. The knowing how to construct a workable unit and make a serviceable product is more essential than the remembering of detailed fundamental facts. The ability to use fundamental data and laws requires only the training of common sense and judgment. This same common sense and judgment is possessed by many persons employed in ceramics without the opportunity of collegiate training; it is the same common sense which promotes from the bench to plant managership.

Professor Orton used to tell his classes in those early years that a collegiate training was no sure short cut to industrial leadership, nor were the experiences had in the class room a substitute for factory experience. The truth of this is more apparent today than it was thirty years ago. Collegiate training in the solving of construction and fabricating problems in ceramics is merely the acquainting of the students with the sources and records of fundamental facts and the means of using them. Judgment in the selection and use of facts in the solving of problems can come only through experience.

Collegiate training cannot take the place of native common sense. The sad record of graduates of universities gives emphasis to the importance of native common sense.

What the ceramic manufacturers lacked thirty years ago, and what they lack to a very large extent today, is a familiarity with the fundamental principles underlying the chemistry and engineering in manufacturing, and particularly the lack of knowledge of how to use these fundamentals.

In contrast to the situation thirty years ago, when the graduates of the collegiate ceramic department could find employment only at a day laborer's wage and did not have the confidence of the employer, ceramic plant owners are now seeking the services of these graduates. It is the testimony of the directors of the several ceramic departments of the universities that their demand for men is in excess of the supply. The service which the men trained in the colleges can render is today more appreciated, and yet there has been no adequate demonstration by these graduates of

the sort of service which will be possible when we shall have learned better how to use the fundamental sciences in the solving of our plant problems.

In comparison with the graduates of other technical and engineering courses, the graduates of the ceramic departments have done well. Maximum and minimum wages earned compare favorably with those of the others, as does the percentage of graduates who finally acquire financial substance and managerial or executive positions. But there is no satisfaction which can rightfully be had in this situation. It merely indicates that such as has been accomplished through collegiate training in ceramics has been worth while. There is a very serious need of taking stock of the situation. There is a need for a frank and studious consideration of how the colleges should prepare their pupils for industrial service. The number of schools giving ceramic courses is multiplying rapidly. Other large institutions are considering establishing ceramic departments. In justice to the pupils who are going to apply to these schools for the training, and to the tax payer who is to meet the expenses and to the ceramic manufacturers who are to employ their graduates, very careful thought should be given to the best and most productive methods of training these pupils for service.

The method of training outlined by Professor Orton thirty years ago is still in use without any great amount of change. The schools are still taking the students through the same steps. They are approaching the problems of compounding of ceramic mixtures from the raw material standpoint rather than from the properties which the manufactured ware should possess. Fabricated wares must have more than appearance; they must possess very definite properties in order to withstand specific destructive influences in their use. Electrical porcelains must have shape, strength and other properties to withstand the stresses and strains, not only mechanical and electrical, but also climatic. Nearly every ceramic ware has its own peculiar destructive agencies to withstand in use. An understanding of the conditions of use of the ceramic products is just as essential as an understanding of the manufacturing processes, and certainly just as essential as an understanding of the composition peculiar in each case.

A review of the problems being undertaken by the Federal Bureaus and by the several industrial laboratories reveals that the major portion of them deal directly with the use of the products and means of so compounding and constructing the products as to withstand the destructive influences in use. These are just as much within the sphere of ceramic engineering as is the construction of plants and the production of wares. The need of these sorts of studies is just being revealed, and with the realization of this need, there surely will be a remodeling of the courses of studies in the university ceramic departments.

As the number of schools increases with the demand for more trained men, and with the enlarging of the scope and use of the Federal Bureaus, the Mellon Institute and other research agencies giving special attention to ceramics, there is a growing appreciation on the part of the plant owners of this sort of service. It is a matter of record that notwithstanding the very large amount of research work and routine testing done by the Fellows of the Refractories Manufacturers Association at Mellon Institute, there has been an increasing number of technical men employed by the refractories manufacturers, not alone in the plants, but also in the sales forces. Increase in employment of technically trained men naturally follows the proving of the value of such employment.

The organizing of plant owners through their respective trade associations in an Institute for the purpose of collaborating in research is the latest and most interesting result of the beginnings which were made thirty years ago in that first class in ceramic engineering conducted by Professor Edward Orton, Jr. Closed doors, hidden notebooks and sealed lips were almost universal thirty years ago; and in contrast, the manufacturers today visit each other's plants, compare notes and discuss freely their technical problems. Rather than guarding jealously their information so as to retain what they suppose to be a vital reason for their employment, the "experts" today are conferring one with another and exchanging information. They find that there is altogether too little knowledge of the fundamentals involved and too little knowledge had by any one of the best methods of applying fundamentals, and that the ability which distinguishes one man from another lies not so much in the knowledge possessed as in common sense in the use of knowledge.

Schools in ceramics will multiply, and the number of research laboratories, both private and semi-public and State operated will increase. We have just entered upon the era of organized collaboration among manufacturers.

Because Ohio State University was the place where collegiate training was first inaugurated, the officers at this University have asked ceramic manufacturers and the several ceramic schools to join with them in the celebration of the thirtieth anniversary of the beginnings of collegiate training in ceramics. The AMERICAN CERAMIC SOCIETY is going to coöperate with the University by meeting on the campus during the week of this anniversary celebration. It is fitting that we review analytically the progress made, but it is far more fitting that we analyze the need of the day and the need of tomorrow in the matter of collegiate training of men, not only for the factories, but also for the laboratories.

The time of this celebration will be the week of February 16 to 21, 1925 inclusive, and the place will be Ohio State University, Columbus, Ohio.

PAPERS AND DISCUSSIONS

MINING OF INDIANA CLAY FOR TERRA COTTA[1]

By L. Behrendt

In the manufacture of terra cotta the supply and uniformity of the raw material are of prime importance. It is needless to say that clay is the chief raw material and to obtain a uniform and suitable supply is of prime importance to the terra cotta manufacturer. Terra cotta is fired to temperatures varying from cone 01, to 7 or 8, depending upon the available clays. The experience of the writer has been limited to the Central District and all statements made in this paper refer only to the conditions prevailing in that section. The terra cotta there is made from a clay which contains a sufficient fluxing material to give a very hard and strong body at cone 01, or 1. This clay is a coal-measure clay. It is obtained from the mining sections in and around Clay County, Indiana.

In the Indiana clay and coal field the uppermost stratum is a yellowish clay, covered with a thin layer of humus. This stratum varies from five to twelve feet in thickness. Immediately below this is a hard shale of a bluish color more uniform in thickness and of an average depth of about twelve feet. This shale rests on a vein of coal varying from two and a half to four feet in thickness. This is properly the third stratum, although, in some places, there is a seam of hard pan or conglomerate between the shale and the coal. This is of some importance as the presence of this hard pan is the source of much trouble and worry to the steam-shovel operator. On the market this coal is known as upper vein block coal. It is a good kiln coal and the screenings are used for boiler purposes. The fourth stratum which is immediately below the coal is a buff burning clay, which is used for manufacturing terra cotta. This stratum due to the conditions prevailing at the time it was deposited, varies in composition. The thickness of the clay in this stratum suitable for terra cotta purposes varies from eight to thirty inches. Beneath the terra cotta clay is found a layer of so-called kidney stones, imbedded in the clay, which varies from three to twelve inches. The lower part of this stratum is a highly siliceous material. The layer of terra cotta clay varies in thickness within small areas throughout the district. The seventh stratum is a blue shale which varies from fifteen to thirty feet in thickness, which might be used for making brick and other dark colored building material. The eighth stratum is what is called the lower vein block coal and varies from two and a half to three feet in thickness. Beneath this coal is found another stratum of clay which at one time was used exclusively by the terra cotta manufacturers.

Two distinct methods of operation are used in the mining of Indiana

[1] Presented by Mr. Thurlimann at the Atlantic City Meeting, Feb., 1924 (Terra Cotta Division).

clay and block coal. First, shaft mining and second, open mining, by stripping the overburden. Shaft mining is far more difficult in the block coal mines of Indiana because as a general rule the overburden does not make a sufficiently strong roof to afford safety in working without very heavy timbering. On the other hand, since the overburden is not very deep, stripping operations are far more satisfactory and economical and are in general use in that region.

The stripping is accomplished by means of a steam-shovel usually of large size so that the bucket will pick up about three and a half cubic yards of the overburden at one time. This is then dropped on the ground where the coal and clay have been removed. The loading of the coal and clay is done by a steam-shovel which is capable of loading from twenty to thirty cars of coal or clay per day of eight hours, but never actually reaches that capacity because the coal and clay cannot be moved away fast enough. In the mining of the clay great care is necessary on the part of the steam-shovel operator to get all the clay without picking up any of the clay iron balls or kidney stones.

Coal mining operations have been carried on in this district for about sixty years. The thicker veins were naturally the first to be worked. The best clays were found beneath the thick coal measures. At the present time there are only a few of the first and second coal measures being operated.

The quality of clay in this district varies so much that it is necessary for the laboratories to make tests on most all cars that are received at the plant. The so-called rubber clay is objectionable because it is hard to mold and it cracks badly in drying. The highly siliceous clays cause cooling cracks. Some of the clays have a high sulphur content, which is present either as pyrites or in the form of soluble sulphates.

Some of these clays, particularly the lower vein burn to a salmon color. The difficulties encountered by the presence of pyrites are blistering and greenish black spots on the enameled surface of the ware. When present as soluble sulphates, the salts are brought to the surface in drying and the slips and enamels do not adhere to the surface of the ware and the result is peeling.

Midland Terra Cotta Co.,
Chicago, Illinois

WHAT IS THE EFFECT OF SELENIUM DECOLORIZER ON THE TANK BLOCKS[1]

By H. L. Dixon

Mr. Dixon: All those who think the use of selenium decolorizer is injurious to the tank blocks are as yet unable to tell just what causes it.

[1] Presented before the Glass Division, Atlantic City Meeting, Feb., 1924.

In a number of cases the blocks in the furnace are damaged and worn away much more rapidly than they were in the same furnaces when they use manganese as a decolorizer. It is a strange thing too that in many instances the front walls of the melting chamber and the bridge wall are worn away more rapidly than the filling end next to the dog house. This is almost a reversal of the conditions existing before.

If a tank is working properly the glass near the bridge has become almost perfectly plain. The fusing and clarifying of the materials has occurred before it reaches that point so that next to the bridge or on the front end of the melting chamber there is a body of glass that is very transparent. We know the heat rays penetrate glass as does light, in proportion to its transparency. Naturally, therefore, without any color in the selenium glass and being more transparent than when manganese was used, some think that the intense heat penetrating the glass to a greater depth is the cause of more rapid erosion.

There is another theory. As furnace builders we get orders for furnaces of capacities from 12 to 75 tons of glass a day. We find that in nearly every case, after operating a year or little more, they have exceeded the rated capacity of the furnace. That has resulted naturally in the last few years from the use of improved feeders and automatic machines. Their calculations of capacity were based upon what they were able to accomplish with the unimproved machines. The productiveness of these machines have increased 25 to 30% since the furnace and the machines were installed. How do they meet that condition? They must increase the melting. They must run the furnace hotter. Consequently they have gotten into the habit of running their temperatures very much higher than previously.

These are a few conclusions reached not only from my own observations but also from the discussion of others who have not technical knowledge of the subject but who are simply up against the practical proposition almost every day. If there is any theory, any scientific solution of this, we should like to know it.

DR. SHIVELY: In recent years, unquestionably the tank builder has improved the efficiency of his tanks. Today it is nothing uncommon to find an actual temperature of 2800°; 2750° seems to be the average. I know of a number of tanks that never run less than 2650°. This high temperature has its influence on the tank block. I know of one particular case where a tank was in operation for 11 weeks at a temperature of 2750°. Mr. Dixon rebuilt this tank from the same blocks. On the advice of the technical men it was run at 2650° for the next fire and lasted 12 months. The temperature condition has a great deal to do with the blocks wearing away.

I know of furnaces in operation that are pulling as much as a ton of glass

on 7 square feet and in some cases they are pulling more than that. The old tank rating was a ton of glass to 12 square feet.

Another thing that has an influence on selenium glass is that today we are getting soda ash that analyzes about 99.6% sodium carbonate. It is a granular ash. It is my belief that polymerization losses in this granular ash are practically nothing. You cannot find any loss by an analysis of ash which is carefully put into the batch. The Lime Association has been working to supply burned lime having ignition loss of around 2%. This means that you are now getting more flux into your glass.

There is a tendency to increase the soda content in order to pull more glass. In machine operation they are pulling the tank six days in a week and usually pulling it hard. In the old hand operation, unless they were working three shifts, the tank stood still for 5 or 6 hours during the day, and when it was started up again the direction of the channel of the glass was changed. Erosion has a great deal to do with wearing the blocks away.

Mr. Dixon has advanced a theory in regard to heat and light transmission. A piece of molten green glass without any decolorizer in it is just as transparent as a piece of selenium glass. Manganese glass, of course, is not transparent but the green glass is. In the old days they considered that the green glass tank would last longer than a manganese tank.

On the other hand, I hear a great deal of complaint regarding manganese pots. They are using manganese pots right along.

The glass manufacturer is anxious to increase his production. He goes to the block manufacturer because of shorter time life. Selenium is the only new thing introduced hence they pass the buck to selenium. They do not consider that in using selenium the resulting saving is approximately a dollar a ton on the glass melted. In a 25-ton tank in 8 months, enough will be saved over the cost of using manganese to rebuild that tank.

The results being obtained must be considered. The tank glass today is better than the pot glass ten years ago. A lot of the contention in regard to selenium being hard on tanks can be attributed to other sources.

DR. SILVERMAN: I have had no experience with the effect of selenium on tanks but I have made selenium ruby glasses in pots. We use from 8 ounces to a pound and a half of selenium per hundred of sand. The pots have lasted anywhere from 22 to 40 weeks. In some cases the pots lasted 50 weeks continuously on selenium ruby. There was no excessive corrosion. So far as that experience is concerned, it would hardly seem to imply that the selenium is responsible for very serious corrosion.

MR. PAYNE: Were these covered pots?

DR. SILVERMAN: Yes.

MR. DIXON: In tanks making colored glasses such as blue, amber and green glass, it is well known that they will last longer than any tanks making flint glass. I do not believe that the fluxes in the flint glass are any

more detrimental to the blocks than the fluxes used in the green, amber and blue glass. Practically the only difference is in the color and the transparency. The tanks making that kind of glass last much longer than the others.

I did not say I thought there was anything in the selenium that would injure the block. I said it was probably due to the heat transmission because of the transparency of the glass which is more transparent than the glass made with manganese. In regard to our experience in using the same sort of lime batch, it used to make our tank blocks show much less pitting after we added selenium to the same fundamental batch.

DR. LITTLETON: I do not have enough information to argue the heat transmission of molten glass. We do know that there is not more than 10% of the visible radiation at those temperatures. The rest of it is non-visible radiation, and while a glass may be much more transparent to that 10%, it can easily be much more opaque to the rest of it. We have glasses which are perfectly opaque to the visible and yet transmit, in a solid condition, a very high percentage of the infra red. Compared to some of the transparent glasses, the reverse is true. There is some evidence which indicates that glass is more transparent to the infra red in the molten condition than it is in the solid condition, but it is mere circumstantial evidence. There is nothing positive to indicate it. It would be rather surprising, from a theoretical standpoint, if it were more transparent to the infra red in a molten condition than it is in the solid condition.

DR. SHIVELY: A manufacturer who is pulling 18 or 19 tons on a 12-ton tank with green glass machines advises me that they do not get the life of tanks they formerly got when pulling 12 tons. Some of these green glasses are so stiff in the bottom that they frequently have to insulate the neck, not particularly in this country but in England, in order to get the glass through.

The life of a tank could be increased if the manufacturer knew a little bit more about how to heat up his tank. The clay people ought to know this. They have been a little lax in not giving advice to the glass manufacturer in regard to bringing up his tank. With the tank full of glass the fires downstairs are lighted. When 500 or 600° is obtained the fires upstairs are lighted. I have seen tanks brought up in a week to 2550°. Every block in a week would be honeycombed; just cracked to pieces.

A case in point may be interesting. A certain factory operates large tanks with 8-inch blocks. Two years ago they were getting 19 months out of their tanks with selenium. He said about that time they introduced the double mold and increased the capacity of their tanks from 30 to 50 tons, and likewise increased the temperature 200°. They are now getting 12 months out of the same tank. I think that illustrates what heat and tonnage do to the life of tanks.

MR. ROSS: I believe that careful observation of the amount and kind of batch filled into tanks and the temperatures of operation will lead to considerable information concerning the properties of tank blocks.

MR. FLINT: How can we make any more observations than we do with a recording pyrometer on temperature and an absolute knowledge of the number of pounds of batch that go in, and checking with an optical pyrometer the heats at the various locations in the tank?

MR. PAYNE: In an amber tank, which we were heating up, the entire bridge wall was criss-crossed with large cracks almost large enough to put one's finger into. Probably there was hardly a space on that bridge wall that did not have one or more of those cracks across it. That tank lasted 33 months yet the bridge wall was absolutely full of cracks. It was our opinion that if the bridge walls cracked in that manner they would go out in a hurry. We have had tanks which did not have those cracks. Some of these lasted well and others went out even faster than those which started with the cracks. It seemed to make very little difference whether or not those cracks were present.

MR. FLINT: What is the idea of drilling a hole in the block when the blocks have a hard enough time as it is. The best thing to do if we want to see what is happening to the block is to build it out of glass.

We have a heating schedule from 11 to 12 days. Generally with a recording pyrometer, it is a straight line heating increment from room temperature up to 2500 or 2600° with the exception of a drop of 100° when we change from the burners inside to the port burners. That schedule was adopted to give uniform heating conditions. Many tank block men were shocked because it took less than 25 days to heat up a tank. My first reaction was, if the men who make tank blocks do not agree better as to how long it should take to heat up, how will the glass maker be able to decide. Some say you really ought to use only 12-inch blocks, that is 12 x 12 or 24 x 36. They burn so much easier. Another one will advise the use of 30 x 36 so as to have less joints. There does not seem to be any unanimity of opinion about such things. And they really are fundamental.

One tank block salesman will see a block he knows to be his competitor's and say, "Do you buy blocks like that with cracks all over them?" And another says, "Yes, they have a few cracks but it does not amount to much." How can we get blocks that are uniformly well manufactured?

Very recently some blocks were delivered to one of our factories in Zanesville. They were odd-shaped blocks, the back end of a flow spout. The cross section of them looked like a U. They had sat in the middle of the freight car and just the jolting of that freight car was sufficient to cause the sides of that U to drop off. It left the imprint of the man's finger marks where he had to put it together. When that block is heated and cooled in use something is going to happen to it. All our blocks are not

like that, but enough of them are so that we wonder just to what extent some of the manufacturers are keeping after those little things. We realize that the man who worries and thinks about that the most is not putting that block together. The thing that makes that a success is the matter of superintendency and foremanship. Users of those blocks do not have a thing to do with this superintendency or foremanship but they have to take that block and take the consequences.

This subject has very recently been so strongly brought to attention. I looked up the records back to 1915. The tank life varied from 50 to 80 weeks in those days. Now it is about 20 weeks. By extrapolating, I calculate that in 1930, they will have no life at all. Our job is to stop this shortening of the life of the blocks before we get to 1930. A man I talked with recently stated that he does not use them any more. They did not last very well, so he began using ordinary 9-inch fire brick.

MR. FINN: About 4 years ago in the Optical Glass Bureau we had a great many pot failures. Probably two pots out of three were in the habit of going through. Recently we changed our firing schedule making it slower in the beginning and finished at a higher temperature. This makes a longer schedule. The difference in the quality of the pots was so very marked that I am sure the manufacturer or the ultimate consumer of tank blocks would be justified in higher firing for his blocks.

A very significant point along that line is the use of these pots for the melting of a dense barium crown. Dense barium crown is regarded as probably the most corrosive glass made. I cannot say that it is more corrosive than a very dense lead (75% lead oxide) melt.

I was asked at what temperature I was going to run this barium crown. He said, "I would like to see some of the glass out of that pot. You will never get it out of the furnace." When we took it out of the furnace according to schedule the pot showed practically no signs of corrosion.

From a chemical point of view, lead oxide is one of the best solvents for refractory materials. I have had occasion to make but two or three melts of dense lead glass, but I may say that it took all the nerve I had to put a 75% lead oxide batch into a pot. I put it in, melted it, took it out, broke the pot, and the evidence of corrosion was very slight. We attribute that more to the firing treatment of the pot and the ultimate temperature of firing than to the quality of the materials. We have changed the pot batch quite a little bit to see what could be done. Within reasonable limits pots can be made of most anything if they are properly fired. I would like to urge that somebody making tank blocks try the effect of firing the pots up to that temperature at which they begin to lose their shape under their own weight. We hold them at these temperatures for about 8 hours and find we have a very wonderful pot.

MR. FLINT: We have very seriously talked with almost every tank block manufacturer about firing to high temperatures. Some of them say, "yes, it would be very interesting." Others will say, "No, it is absolutely unnecessary and useless time, labor and fuel to spend to do it." Others will say, "Some time we hope to do it." All of these men apparently have very thoroughly and seriously considered their own product. Part of the argument which they give against firing a block to 2600 or 2700° or even more, is that in the tanks they do not get to that heat. They say that not over 2 inches of the top rim which is above the surface of the glass and facing inside the tank gets to that heat.

MR. BROWNLEE: We fired 4 different batches of blocks at 2750°C. With these we built an experimental tank at the Owens Bottle Plant, and we ran a test for 6 weeks. The large tank had to be let out at the end of this 6 weeks hence naturally this experimental tank had to be cut off. We then enlarged the tank. We built it up with fire brick in three places exposing the fire brick to the glass. On letting the tank out we found that there was a slight wearing of the tank blocks, but there was no more wear shown on the tank block than there was on the fire brick. The fire brick was just flush with the tank wall. This experiment was not carried to completion. I think it is a very good idea firing the block higher. We are now firing our blocks to 2550°.

MR. FLINT: Did you use pyrometers or cones?

MR. BROWNLEE: Both.

I feel that the smaller the block is, the much easier to fire. The heat goes all the way through the block where it would not on a large block.

MR. MONTGOMERY: It seems as if one point has been missed in this tank block discussion, and that is the composition of the tank block. In optical glass manufacture, which includes everything from the ordinary soda-lime glass, which is not markedly corrosive, to the glasses of high barium and lead content referred to by Mr. Finn, we have to develop a pot which will suit each particular glass. The pot should mature and have the proper physical properties at the temperature at which the melt is to be made. A pot which will give satisfactory service at 2550 to 2600°F will seldom give equal service at 2650 to 2700°F. The composition of the pot will have to be changed to give the required properties at the higher temperature.

We melt some of our barium glasses at 2300 to 2350°F. It was necessary to develop a pot which would mature at this temperature or fire the pot to the temperature at which the necessary physical properties were developed. We fired the pots, used for this glass, at 2550°F.

If a very fluid glass like the densest barium glass is melted in an underfired or porous pot, it will run through the pot like water through a sponge. The glass will penetrate the pore space and seep out into the furnace. If

the same pot is fired to the point where it is dense, this filtration or seepage will be stopped. The point illustrated by this extreme case will apply to all pot making. The manufacturers of glass house refractories often do not realize the variety of conditions their products are called upon to meet. They do not suit their batch composition to these conditions. A commercial batch is expected to answer all purposes. This will never be satisfactory. The pot manufacturer must specialize more before much headway will be made.

MR. MERRITT: I have had no practical experience with these blocks, but I recently made thermal expansion tests on clays. The shape of the thermal expansion curve changes very definitely with the intensity of firing. The results obtained confirm Mr. Flint's statement that if a block or any clay material is to be used at a certain temperature it should be fired to that temperature and perhaps a little higher.

MR. FLINT: We have a couple of tanks, the blocks for which we would like to have fired to 2750°. Would it be possible to get such blocks?

MR. BROWNLEE: I believe the clay would stand it. It would be more expensive, but I think in a smaller block it would be possible.

MR. FLINT: Could it be done commercially with the present type of kilns you are using?

MR. BROWNLEE: Yes.

We fired the blocks that I mentioned in that experiment in a special small kiln. We would like to try it.

MR. FLINT: You will have the chance.

MR. FULTON: I do not believe that the majority of block makers' equipment for firing tank blocks would stand any such temperature. In fact very few of them are in a position to fire to 2750° without constructing a special kiln for the purpose.

MR. DIXON: Mr. Brownlee is right in his theory of a smaller, thinner block. If any of you have had occasion to cut some of the large blocks in half you have noticed that in the larger block, the center is often almost as black as coal. This indicates that the block was not thoroughly dry before it was fired and that in the firing they forgot that all that moisture in the middle of the block had to be driven out. This discoloration in the block is something I do not understand. It has been proved time and again however, that it is due to the moisture left in the block before it is put in the kiln. If the blocks could be fired thoroughly all the way through at about the temperatures to which they are later submitted, it seems to me that they would stand up much better. Sometimes you find in the wall of a tank one or two blocks that have peculiarly stood the test they were put to, much better than all the adjoining blocks, and nine times out of ten it is a block that is well fired.

Consider the conditions to which a 12-inch block in the wall of a tank is

subjected. It has not only the corrosion of the metal on the inside, but it has the higher temperature on the inside and is cool on the outside. Is not that liable to break the structure of the block? We have just heard about the expansion and contraction of the clay. This difference in temperature is bound to break the structure. The block will not stand the heat when it is insulated.

A few years ago Mr. McNeelye, from Australia, told me that during the war they could not get tank blocks for reconstruction of their tanks. They had to go out of business for a while. Finally they discovered a bed of sandstone which they thought might serve the purpose. They cut the sandstone into blocks. These sandstone blocks outlasted any clay blocks they had had. The stone was very close grained soft sandstone. It could be cut with a saw. It hardened as it got dry, but it did not seem there was any particular quality in that stone that would make it last longer than clay blocks.

The Old Dominion Glass Company had two tanks in operation built of silica brick. They generally lasted two years before needing repairs. These furnaces were like big canal boats. They had a crude sort of producer on one side and a port leading directly into the tank. They did not have a bridge; simply boots deep enough to skim the glass. The brick stood up in that stew pot, as I called it, for more than two years.

They were so impressed with the idea that silica brick were better than clay tank blocks that they insisted on the use of silica brick in their modern furnaces. We took the precaution to build the furnace such a way that the silica brick could be easily removed and clay blocks substituted. We built a furnace that ran much higher in temperature than the old furnace. Five weeks after it was started, I got a telegram to hurry a set of clay blocks to them. The silica brick had melted away and were almost all gone.

The block people are constantly trying to improve their products. All of them recognize what they are up against. They are required to meet conditions now that never existed before in all their experience. They have nothing with which to make blocks except the raw material in the ground. All they can do is to improve their treatment and improve their methods of making blocks. The service which tank blocks have to give today is twice as much as they formerly had to give.

MR. ROSS: If we fire blocks as dense as a pot that has been in service a few weeks, is it not probable that we shall have to give very careful attention to the thermal strains set up during heating and in use?

MR. YUNG: No tank is stronger than its weakest point. It may be the life of the water cooler, but not the life of the blocks that determines the life of the tank. What do we mean by the life of a tank?

The heating schedule seems to me to be of most importance in tank operation. The expansion of a clay block or of a silica brick is not the same

throughout the entire range of heat treatment and vitrification. There are two points which are the most delicate. The first is the water smoking period, so called. It is a matter of safety that the lag between the temperature of the block and the temperature of the furnace has to be carefully overcome. This water smoking period is from the start of the fires up to 300°C. The second critical stage is from 500 to 600°C. This is the temperature of dehydration and oxidation. Beginning here also is the breaking down of the clay molecule.

The point I wish to bring out is that a straight line preheating schedule may or may not be a good practice. The practice I have adopted is to run from atmospheric temperature to 300°C at a rise of $2^1/_2$°C per hour, and from there on up to melting temperature at the rate of 10 to 12°C per hour.

Another important thing is the firing the clay pots and block at highest possible temperature. Also of importance is the method of filling the tank while heating up. The schedule I have adopted includes a two day soaking heat at the highest temperature. That soaking heat is the maximum temperature that the furnace will stand—perhaps, in the neighborhood of 1500 and 1550°C. This seems to have a marked effect upon the lasting qualities of the tank.

At the start the glass is put into the tank for glazing purposes. It is banked up against the side, and the total bulk of cullet put in is only sufficient to cover the side wall. When melted it amounts to about 2 inches on the bottom. Another method I have seen used is to shovel in the cullet in a uniform layer practically filling the tank. There is a marked difference in the corrosion by the two procedures. With the cullet filled to the metal line the joint between the first and second course gets a very light firing and I think this is the cause for increased corrosion at the joint.

MR. WILLIAMS: We should decide to bring in enough discussion or information to next year's meeting to decide two points. The first point regarding tank blocks is, what percentage of the loss or wearing away of the tank block is corrosion and what percentage is erosion. The next point is that which Mr. Yung has just emphasized *viz.*, what are the relative kinds of results, or the type of result, the finished result, from different methods of heating up the tank in the beginning. That seems to me to be very important. If Mr. Yung's observations hold generally it is very important. Indeed, it seems to me that 90% of the loss of our tanks is due to corrosion or to the lack of refractoriness, and 10% to erosion. If this is true we should immediately begin to consider refractoriness of the blocks of prime importance.

I suggest that whoever has charge of the program next year should remind the members of the Division that we would like to have all the information possible about these two subjects. Refractories to the glass maker

means a great many dollars and cents, and it would be worth while continuing these discussions, but let us bring them down to a couple of definite points and not range all over the many defects.

Further Discussion on Selenium

By R. R. Shively

I have listened with interest to the discussion of this subject by the previous speakers. Having used selenium for a number of years, I have given consideration to possibly every phase of its use and have at last decided that there is no one thing that one can say is the cause of the tank blocks not lasting as they formerly did. It is my opinion that there has been a decided improvement in the tank furnaces during the past few years. The furnaces now being built are capable of higher temperatures and my experience leads me to believe that practically all glass manufacturers are inclined to play safe and run the tank as hot as it can be run. In several instances the actual temperature being carried is close to 2800°F and at present there is no refractory that will withstand this temperature over a long period.

I know of one instance where a tank was operating at a temperature of 2750° and only lasted eleven weeks. This same tank was rebuilt with blocks from the same manufacturer and operated over a period of twelve months at a temperature of 2550°. You might be interested to know in this particular case that they were able to get as much tonnage at 2550° as they had previously secured at the higher temperature. Of course in this instance it means that the tank was not being pulled up to capacity at the higher temperature.

With reference to this particular phase of the subject, I recently had a letter from the superintendent of a very large factory who informed me that up until two years ago, the life of their tanks averaged eighteen to nineteen months, but since that time they had increased the pull on the tanks from thirty to fifty tons in 24 hours and in order to do this, it was necessary to increase the temperature 200°, and as a result the life of the tanks was reduced to twelve months. Just within the past few days, I have talked with a very prominent manufacturer who claims that he does not now get the life out of tanks which he formerly got on manganese, but in this discussion he told me of the wonderful improvement in his tanks and of the high temperature which he could now obtain.

Within the past four or five years, there has been a very decided improvement in the heavy chemicals supplied to the glass manufacturer. Today, at least some of the soda ash manufacturers are supplying soda ash that analyzes not less than 99.5% sodium carbonate and this is being fur-

nished in granular form in which all of the fines have been screened out, and it is my belief that this has greatly reduced the volatilization losses of soda, which together with a greater purity being supplied, increases materially the soda content in the finished glass.

The high alkali glasses have undoubtedly more fluxing action than those containing a lower percentage of alkali. Due to the educational work of the National Lime Association, burned lime is now being supplied which has an ignition loss of only approximately 2%. This means that the manufacturers are getting more lime in their glass and this too may have its influence on the rapid fluxing of the blocks. Unquestionably all of the members of this Division realize that in the past few years, practically all of the manufacturers have introduced mechanical feeders and machines for shaping the glass. The results have been that the pull on the tanks has been increased and the tanks are now operating six days a week without any stops, consequently there is a constant drag in the walls and I do not believe it can be disputed that erosion has considerable to do with the wearing out of the blocks. When the tanks were worked by hand, there was always a stop in the morning from two to seven which permitted the glass to plain and which always gave an opportunity to change the direction of the pull. There seems to be an over production of glass at the present time and competition is very keen. Labor costs are high, chemicals are high, fuel is more expensive and yet the finished ware is selling at reduced prices. The results have been that the manufacturers have tried to overcome these conditions by increasing their production and in order to do this, they have resorted to higher temperatures and in some cases, more soda and naturally the life of their tanks has been reduced.

Recently an old glass manufacturer remarked to me that better looking tank glass is now being made than the pot glass which was produced ten years ago. The results being obtained are really beyond belief. When this is taken into consideration along with the fact that the saving in the use of selenium amounts to not less than one dollar a ton on the glass melted, it can be readily seen that on a twenty-five ton tank, operating for eight months, the savings will be sufficient to rebuild the tank.

On account of the superior results obtained with selenium and this saving, I do not anticipate that many manufacturers will go back to the manganese even if its use could be proven to give longer life to tanks which I doubt would be found the case under present operating conditions.

If you will please excuse the common parlance, I do not want to be understood to be "passing the buck" to the block manufacturers, but I believe that if they would take more interest in educating the user of their product as to the correct way to bring up the tanks, better life would be obtained from the blocks.

In summarizing these remarks, it impresses me as a round robin proposition. The glass manufacturer has appealed to the tank builder because his tank does not last, the builder in turn blames the block and the block manufacturer attacks selenium because it is the only new substance generally used in glass. Selenium has served the manufacturer well at a time when it was badly needed and unless I am grievously misinformed, the results obtained and its monetary savings shown, justify its continued use.

It is impossible to determine the amount of selenium actually necessary for decolorization. The average amount used in the batch is less than one part in 80,000 parts of finished glass and as some of this is lost by volatilization or oxidation, it is quite impossible to find by analysis the amount of selenium remaining in the finished glass.

A few manufacturers do not use arsenic and the amount of selenium required for their batch is unusually small. I know of one factory where raw materials of low iron content are used, that requires but .125 ounces of selenium combined as a selenite, to decolorize a thousand pounds of sand. Another factory not using arsenic, but using the element, requires but .25 ounces of selenium for a thousand pounds of sand. Where the average amount of arsenic is used, two pounds to the thousand of sand, the amount of selenium required to the batch is about .4 of an ounce. Where a selenite is used, even a smaller quantity is required. It can be seen from the above facts, that very little selenium is required for decolorization, and if any unusual amount of it is lost through furnace conditions, it would seriously affect the color.

As to the properties of selenium, it melts at 217°C, it burns in the air with a bluish red flame, forming selenium dioxide, and boils at 690°C. From these properties it would be expected that some of the selenium introduced in the furnace is lost by volatilization, and in the case of a tank operating under oxidizing conditions, some of the selenium may combine with oxygen and the selenium dioxide carried out with the stack gases.

Let us consider for the time, ruby glass, where a much larger amount of selenium is used. Ruby batches made in pots require much less selenium than those made in day tanks. In the latter case, I am informed that everything depends upon the flame—a certain batch may give a good glass one day, and the next melt may be unfit for use. The fumes of selenium can be seen escaping from these tanks. If, where larger amounts of selenium are used, the operation of the furnace is so important, it certainly has its influence in a lesser degree where small quantities are employed.

It has been my experience that the hotter the tank is run, the less selenium is required for decolorization. This may be explained by the

fact that where high temperatures are obtained, the furnace is being operated efficiently and a neutral condition is maintained within the furnace.

Unquestionably tank conditions affect selenium decolorization. Constant temperatures and uniform furnace conditions must be maintained in order to get the best results.

WASHINGTON, PA.

DISCUSSION ON "STUDIES OF THE THERMAL CONDUCTIVITIES OF SOME REFRACTORY MATERIALS"[1]

J. SPOTTS MCDOWELL: In this paper, the mean conductivity between 650° and 1250°C is given as follows:

Silica brick	0.00099
First quality fire-clay brick	0.00169

The conductivity of silica brick therefore appears to be about 58% that of fire-clay brick.

O. T. Green[2] found the conductivity of silica brick to be about 80% that of fire brick. Other investigators, including Boyd Dudley[3] and Goerens and Gillis,[4] report it to be 15 to 25% higher than that of fire brick.

In this connection, it is well to refer to the fact pointed out by W. A. Hull[5] that the conductivity of the refractory is only one of several factors working in series which determine the amount of heat flowing through a wall. Other factors are the "diffusivity," the effects of joints and surface resistance, of the luminosity of the flame, draft conditions, whether positive or negative, absorption by the refractories of material from the gases, and glazing or vitrification of the hot surface of the brick.

In furnace practice it is known that more heat will pass through a silica wall than through one of fire-clay brick of equal thickness. The use of silica brick in by-product coke ovens has shortened the coking time. In a paper by F. A. J. Fitzgerald,[6] some interesting figures are given. Furnaces were constructed of hollow cubes with external sides of 230 mm. and walls 60 mm. thick. The furnaces were supported on knife edges so that all sides were exposed to the air, and were heated by nichrome resistance

[1] *Jour. Amer. Ceram. Soc.*, **7** [1], 19(1924).

[2] "The Thermal Conductivity of Refractory Materials at High Temperatures," *Trans. Cer. Soc.* (Brit.), **21,** 394(1921–22).

[3] *Trans. Am. Electro-Chem. Soc.*, **27,** 336(1915).

[4] *Ferrum*, **12,** 1, 17(1914).

[5] W. A. Hull, "Thermal Conductivity of Refractories," *Chem. Met. Eng.*, **27,** 538 (1922).

[6] *Trans. Amer. Electro-Chem. Soc.*, **22,** 110(1912).

wires. The following figures represent the amount of energy required to maintain constant temperature conditions within the furnace.

	Watts lost through walls, temperature °C		
	500°	700°	800°
Fire brick	475 w.	770 w.	930 w.
Silica brick	565	920	1100
Magnesia brick	860		

	Ratios: Heat lost, temperatures °C		
	500°	700°	800°
Fire brick	1.00	1.00	1.00
Silica brick	1.19	1.19	1.18
Magnesia brick	1.81	....	....

Another way of comparing these results is as follows:

With a power input of 860 watts, the following temperatures could be maintained in the furnace:

Magnesia Lining.....	500°C
Silica brick lining, about.....	670°C
Fire brick, about.....	755°C

DEFINITION OF THE TERM CERAMICS AND PROPOSAL OF INTERNATIONAL STANDARDS

RUDOLF BARTA (Dr. Ing.):[1] The Czechoslovak Ceramic Society sent its delegates to the International Congress for Applied Chemistry in Copenhagen, Denmark. I shall mention the point of view which we have in respect to the treating of the Ceramic Division:

1. Name "Ceramic"

The Czechoslovak ceramists are well informed of the suggestion of the commission of the AMERICAN CERAMIC SOCIETY that the name "Ceramic" may be used also in other branches than clay working.

This proposal follows the aim of simplifying the denomination for relative branches of industry. This proposal has however met with certain difficulties:

(1) The way of production in cement, lime, glass and enamel branches rather differs from that of clay working.

(2) The denominations of cement, lime, glass, enamel, etc., are in general use, and by them are directed the international contracts, railway-tariffs, custom-tariffs, statistics, etc.

(3) The introducing of the American proposal would cause changes in the international relations correspondence and record. It may even cause chaos, and a certain chaos in business connections.

If there is the endeavor to introduce a common denomination for the branches of clay working, cement, lime, glass, enamel, etc., then according to our opinion it would be better to choose quite a new denomination. After the proposal of Prof. Dr. Ing. O. Kallauner, it would be for instance "silicates and the respective branches," or abbreviated "silicates"—as it is already in use in Czechoslovakia. Perhaps another more suitable denomination will be found.

[1] General Secretary of the Czechoslovak Ceramic Society.

2. Nomenclature

The Czechoslovak Ceramic Society welcomes the proposal that in all countries commissions be appointed for standardizing ceramic nomenclature. These commissions should be in connection with the international one, in order to effect unity.

3. Designations of Types and Specifications

Czechoslovak Ceramic Society consents in principle that the types of ceramic raw materials may be fixed. It will have a considerable importance in furthering scientific research.

For the international types the Czechoslovaks recommend of their raw materials the china-clay of Sedlice (Zettlizer kaolin) and blue clay of Vildstajn (Wildsteiner Blauton). Both are of equal quality, well known in the world, and a whole series of scientific experiments was made with them.

Besides we beg to recommend that types of local importance be fixed in every respective country.

4. Technological Works

Messrs. Le Chatelier and Lapsa have proposed to compile a certain number of works on ceramic technology. This in Czechoslovakia is not considered as pressing. We beg to draw your attention to some works done in the United States.

For instance, works on chemical analysis of silicates could scarcely be made better than those of Hillebrand, etc.

5. Proposals of Czechoslovak Ceramic Society

To the international conference in Copenhagen the Czechoslovak Ceramic Society has sent these four proposals:

(*a*) Make the comparative experiments between the tests in laboratories and tests in practice.

It is known that the tests on specimens formed in laboratories give different results from tests executed by the same methods on the same raw materials in practice.

Such comparative tests have already been introduced by the Czechoslovak Ceramic Society. The head-man of these investigations is Prof. Dr. Ing. O. Kallauner.

(*b*) It would be advisable to make the international unification of ceramic testing.

(*c*) The elaborating of an International Ceramic Chart would be of significance. It should contain the chief deposits of ceramic raw materials and the chief factories. A list with explanations should accompany.

(*d*) By noting of the ceramic formulae it is recommended to state not only the chemical and rational composition, but also the analysis of grain size, etc. These would make the descriptions of one meaning.

DR. E. W. WASHBURN:[1] I have read the recommendations of Dr. Barta. I believe his suggestions and comments, under Nos. 2, 3, 4 and 5, are excellent and well taken.

With regard to No. 1: His principal objection to the definition of the term "Ceramic" is based upon the difficulty which would be caused in business relations. This objection was brought up and thoroughly discussed at the meeting of the Committee of the International Union which passed upon the question and because of this difficulty the Committee voted to approve the definition *for scientific and technical purposes only*, not for business or trade purposes. With this limitation on the definition the objections of Dr. Barta no longer hold.

[1] Recd. July 21, 1914.

REFRACTORIES QUESTION BOX[1]

E. E. AYARS, EDITOR

Questions

1. Does the grinding (coarse or fine) have anything to do with the resistance of a fire clay to spalling?
2. What difference is there between the properties of a soft mud machine made and a hand-made brick?
3. Can an iron-free clay brick be made for blast furnace service?
4. Will results in service justify the expenditure and added cost necessary in order to make fire-brick mixes from definite percentages of definitely sized clay grains?
5. What effect do soluble salts (such as show on red burning clays as scum) have on the refractoriness of fire brick? Are the silicates formed with such salts in burning of low refractoriness?
6. What effect do sand and air inclusions (commonly called sand cracks or molding cracks) incident to hand molding, have on the service of hand-made fire brick?
7. What is the cause of rapid failure of fire brick in the checker work baffles of oil-fired boilers, subjected to a temperature of 2300°F but against which the oil flame does not impinge? The failure consists of premature vitrification and carbonizing with subsequent fusion. Is this a result of subjecting the brick to a reducing atmosphere?
8. What is the reason for the more rapid failure at a lower temperature of fire brick subjected to reducing atmosphere than will obtain with the same brick under oxidizing conditions?
9. What is the relative spalling tendency of fire brick under reducing and oxidizing conditions, respectively?
10. At what temperature does fire clay break down into sillimanite and quartz? Are the crystals thus formed actual sillimanite or are they the newly discovered mineral $3Al_2O_3$-$2SiO_2$?
11. What properties should a clay brick possess to give good service in rotary cement kilns?
12. What properties should a clay brick possess to give good service in vertical shaft lime kilns?
13. How can the water content for wet pan charges be gaged?
14. What simple laboratory tests can be used to keep the quality of refractories up to standard?

Question

How can the water content for wet pan charges be gaged?

Discussion

The following extract is taken from a paper, "How Good Silica Brick are Made," published in *Brick and Clay Record*, October 16th (1923).

"European silica brick manufacturers have realized the importance of standard grinding practices and much has been done to develop methods of scientific control. The grinding is usually done in medium sized wet pans driven by individual motors. The motors are severally connected with recording ammeters which have charts in plain view of the pan oper-

[1] See note, *Bull. Amer. Ceram. Soc.*, **3** [7], 258(1924).

ator at all times. By experimental runs the desired size of grain, quantity of water and length of run was determined. The ammeter record charted the course of each grind and a standard chart was adopted for daily use. This method insures uniform grinding and tempering results. In one case the first five minutes of the cycle is consumed in dry grinding,.... The reduction in amperage is very noticeable when water is added and when the recorder pen recedes to a certain specified point the water is turned off. The grind then continues about fifteen minutes until at a predetermined point in the cycle the pan is emptied and a new dry batch of material added. Very accurate results should be obtained with this method. By referring to the ammeter chart one may note the relative power consumption of an empty pan and of both the wet and dry grinds."

It appears that the method described for silica brick can be easily adapted to the tempering of fire clays, although another means of indicating the power consumption of the individual pan would have to be devised in the case of line shaft drives. Such an indicator could be developed by a good instrument maker.

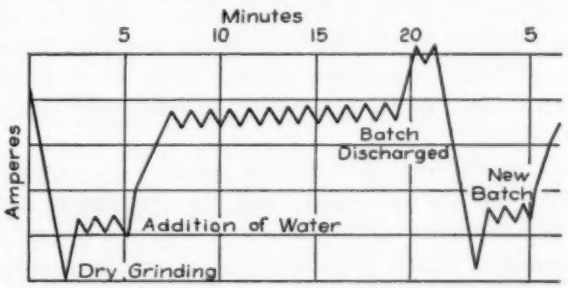


FIG. 1.—Ammeter chart used in European works to provide uniform grinding and wet pan tempering of silica brick mixtures. A 20-minute cycle is used which was determined by experiment to give the results required. Can be adapted to wet pan tempering of fire clay mixtures.

This method automatically takes care of the variations in the moisture content of clay from the storage pile or mine, a problem which has precluded the possibility of obtaining uniform results by weighing the charge and the water to be added.

It has been established that concrete mixtures should contain just enough water to wet the material through thoroughly, and tests have been developed to check the consistency of the mass. The "Slump Test" as applied to concrete consists in filling a conical cylinder with the mixture and striking the excess material from the bottom of the inverted cylinder. Placing the cone on a board the metal shell is removed and set down beside the test piece. By placing a rule across the top of the mold and measuring down to the top of the test piece the amount of settle is determined, and this indicates whether or not the mixture has the proper amount of water in it.

A similar test might be developed for testing the consistency of clay from the wet pan. However the fact that clay is plastic and not liable to settle

enough to form a basis of judgment it would be necessary to use some sort of apparatus to exert pressure on the test piece.

The Vicat needle may suggest a possible test.

However the use of such tests as this takes more or less time and probably would not operate within fine enough limits to be of as much value as the recording indicator as used in Europe.—ED.

Question

What simple laboratory tests can be used to keep the quality of refractories up to standard?

Discussion

The simplest test and one which has a direct bearing on size of grain, water content and molding methods, as well as temperature and speed of drying, is the green brick modulus of rupture. The green brick modulus may be correlated with the burned brick modulus of rupture and other tests. Results recorded on daily tests which do not fall between certain well defined limits are known to have been taken on a product below standard.

Assuming that the chemical analyses of the various clays entering the brick mixture are correct and the proportions properly taken, one test which indicates the uniformity or lack of uniformity of the manufacturing treatment should be sufficient check on the quality of the product. The test should be taken at various specified intervals during the day.

The test suggested will also indicate variations in the proportions of clays in the mixture. For a more complete discussion refer to Question Box department for May and July "Laboratory Control in the Manufacture of Refractories," *Bull. Amer. Ceram. Soc.*, **3** [5], 162–168(1924), and **3** [7], 259–261(1924).—ED.

With further reference to the discussion of the failure of fire brick checkers in oil-fired boiler furnaces which appeared in the August number Question Box, R. F. Ferguson of Bolivar, Pa., formerly with the Refractories Industrial Fellowship at Mellon Institute, has submitted the following information, which has at his request been written up by the editor. Conclusions drawn are by the editor. The study of refractories failures in oil-fired boilers has included analyses of the slags formed, to provide a basis for the solution of the problem. In such investigations the slags have invariably been found to contain high percentages of titania varying from 6 to 10 per cent. This is much in excess of the usual percentages found in fire brick, which seldom if ever exceed 2 per cent titania. Some samples examined also contained small percentages of vanadium in addition to the titania. Several check determinations were made in the laboratory before the analyses were accepted as the high titania content and

especially the presence of vanadium had not been reported in any previous investigation which had come to the notice of the chemist, or the client.

The source of the slag samples cannot be identified at this time and the condition of the refractories from which the slags were collected was not recorded at the time of analysis. The analyses of brick used were furnished as a part of the working data and for comparison with the slag analyses results. Samples of slag submitted were taken from different parts of the country and while the oils in use were not specified and no analyses furnished it seems fair to assume that several representative grades of oil from the various fields were used.

In this connection there has come to the editor's attention a report of some recent work by the Northern States Power Company, "The Effect of Coal Ash on Refractories" by J. J. Brennan.[1] It appears that fuel oil residue should bear a close relation to coal ash, and in the absence of any exact analyses of fuel oil residues the following discussion assumes that the compounds present are essentially the same as are found in coal ash.

The Northern States Power Company studied the effect of ash from nine different coals on fire brick. Test cones were made using 70% of 60-mesh ground fire brick and 30% of 60-mesh coal ash. Nine coals commonly used in power house work and 42 different brick were examined. Analyses of representative brick were made, and the complete analysis of each coal ash determined. Test cone mixtures for each brick were made with each of the nine coal ash samples. Careful fusion tests were run off and the results plotted. The information presented is very interesting.

A review of the coal ash analyses shows the following variations: Silica 38.70% to 55.01%; Alumina 21.76% to 30.75%; Titania and iron (reported together) 6.07% to 23.14% (five analyses showed 6.00 to 10.00% titania and iron, while the remaining four showed 15.67% to 23.14%); Lime 1.15% to 11.47%, the average being 6.04%; Magnesia 0.90% to 2.59%; Sulfur trioxide 0.57% to 7.06% the average being 3.71%; alkalies 1.08% to 3.48% (3 samples undetermined).

Fire brick analyses on 14 samples showed a silica content varying from 25.65% to 61.58%, alumina content from 34.60% to 70.51%, titania and iron from 0.32 to 5.70 (the average being 2.03%). More complete analysis of eight samples showed variations of lime from 0.33 to 0.61%, magnesia 0.26% to 2.91%, alkalies 0.45% to 1.55%.

After a hasty study of the charts on which the results with each set of cones were plotted the following conclusions are drawn by the Editor. First: That the coal ash containing high percentages of titania and iron were most destructive to fire brick. Second: That fire brick containing

[1] Published in June, 1924 issue of *Combustion*, Combustion Publishing Corporation, 43 Broad Street, New York.

high titania and iron were more readily attacked by the coal ash. Third: That fire brick having a high silica content are most susceptible to attack by the coal ash than those brick having an alumina content of 45 per cent or more. Fourth: That there are some inconsistant results which occur when the magnesia and lime contents of both brick and ash are high. In this case low fusion points were obtained where the high magnesia and lime of both substances crossed.

The brick showing the highest resistance to the effect of the ash in all cases has the following analysis; silica 25.65, alumina 70.51, titania and iron 1.90, lime .61, magnesia .49, alkalies .84, and this brick has been adopted as a standard lining.

The author of the article cited above stated that the problem was not one "in which chemical quantities can be assumed, and no attempt is made to impose a theory to indicate, from a purely chemical standpoint, the effect of coal ash of fire brick." In his summary he states that "the actual performance of a number of brick tested has been observed during the past two years and in a majority of cases the actual life of furnace linings follows very closely the indications given in the chart."

However the data presented would permit of more careful study. The same procedure may be extended to fuel oil residues where without doubt much the same results will be encountered. The Northern States Power Company used this method to select the best brick for their purpose but there is a great deal of information in the results which has not been interpreted, and it may be the foundation for which the industry has been looking, on which to build a perfect boiler refractory.—ED.

Question

What is the fusion point and specific gravity of tridymite? Of cristobalite?

	Tridymite	Cristobalite
Fusion point	1670°C (Searle)	1625°C (Searle)
Sp. G.	Artificial tridymite, 2.27 (Fenner)	Artificial cristobalite, 2.333 (Fenner)
	Natural tridymite, 2.28 (Mallard)	Natural cristobalite, 2.34 (Mallard)
		2.32 (Searle)

ACTIVITIES OF THE SOCIETY

NEW MEMBERS RECEIVED FROM JULY 15 TO AUGUST 15

PERSONAL

Bramhall, Riley, Holmesfield, Sheffield, England, Works Manager, Moor Edge Silica Brick Works.

Carrie, G. M., Magnesite-Prov. Quebec, Canada, General Manager Scottish Canadian Magnesite Co., Ltd.

Corman, Julian, 1808 Walnut St., Murphysboro, Ill., Ceramist, Isco Bautz Silica Co.

Frazier, John Earl, Clarion, Pa., Chemical Engineer, Berney Bond Glass Co.

Le Heron, Revin (Ardennes), Director, Des Etablissements Porcher.

Lukens, Glenn, 502 E. Chapman St., Fullerton, Cal., Instructor.

Lyons, Sanford C., Bennington, Vermont, President, Vermont Kaolin Corp.

Simpson, Harold E., 87 Tibet Road, Columbus, Ohio, Student.

Weaver, Eduard E., 151 Alabama Ave., Providence, R. I.

Membership Workers' Record

	Personal
Howells Frechette	1
William Hugill	1
C. W. Parmelee	1
John Sawyer	1
Office	5
Total	9

THE SUMMER MEETING

Fred B. Ortman, general chairman of the 1924 Summer Meeting Committeew rites that the California members are looking forward to October 6 and 7 with great anticipation. They are doing more; they are making sure that the realization will equal the most exaggerated anticipations.

Two days' program of technical papers and plant visits followed by directed plant tours as those in attendance will choose are on the schedule of events.

Round trip tickets at excursion rates will be available. Ask your local railway agent for routes and rates with Hotel Biltmore, Los Angeles, Calif., October 6 and 7 as your objective.

RESEARCH COMMITTEE MEETING—ENAMEL DIVISION

(American Ceramic Society, Held at Hotel LaSalle, Chicago, Illinois, on July 7, 1924)

PRESENT—MEMBERS OF COMMITTEE

M. E. Manson,
Rundle Mfg. Co.

W. G. Lindemann,
Lindemann & Hoverson Co.

BY INVITATION:

P. H. Bates,
Bureau of Standards.

C. M. Pearson,
Pickands Brown & Co.

E. P. Poste,
Pfaudler Co., Elyria Division.
L. G. Wassman,
Wolff Manufacturing Co.
Homer F. Staley, Chairman,
Metal & Thermit Corporation.
J. A. DeCelle,
Chicago Hardware Foundry Co.
R. C. Boyd,
Chicago Hardware Foundry Co.
R. R. Danielson,
Lindemann & Hoverson Co.

Presiding Officer: R. R. Danielson, Chairman of Enamel Division.

The Chairman of the Committee gave a brief résumé of the chief research work to be undertaken this year. This is an investigation of the relations between the composition and structure of cast irons and their enameling properties. The Bureau of Standards has consented to do a large amount of research work on this problem with the advice and coöperation of the Enamel Division. The Metallurgical, Ceramic and Chemical Divisions of the Bureau will take part in the investigation.

After some discussion, it was decided that the first series of experiments should deal solely with the relations of structure in cast iron as effected by the percentage of scrap used in producing it and by the number of times the iron has been remelted, when the chemical composition is kept uniform. Other phases of the subject will be taken up later.

The following tentative program, subject to modification by the Bureau of Standards, was approved.

Cupola Melts

Series 1.—To find the effect of varying percentages of scrap in melts.

Melt 1.—100% Pig Iron. Part of this to be used in the following melts as scrap.

Melt 2.—20% Scrap
Melt 3.—40% Scrap
Melt 4.—50% Scrap
Melt 5.— 60% Scrap
Melt 6.— 70% Scrap
Melt 7.—100% Scrap

Series 2.—To determine the effect of repeated meltings on structure of iron. A certain amount of pig iron will be melted and test samples made. The remainder, with the addition of only enough raw pig iron to bring the composition back to that of the original mixture, will then be remelted in the same manner five or six times unless the iron becomes unworkable in a fewer number of melts.

Series 3.—Will be the same as Series 2 but with the use of soda compounds in the ladle to keep down as much as possible the gradual increase in sulfur due to remelting.

Composition Desired in all Castings:

Silicon	2.25 plus or minus 0.10
Sulfur	0.10 plus or minus 0.02
Phosphorous	0.65 plus or minus 0.05
Manganese	0.50 plus or minus 0.05

Coke.—Solvay coke containing 0.50–0.60 sulphur, ash 7–8%.

Cupola Practice.—To be kept as uniform as possible. 2½% of high calcium limestone is to be used as flux.

Molding of Castings

Castings.—3″ × 6″ × 3/16″. Cast four on a gate with the use of a spoon gate. Albany No. 1 sand to be used. No facing to be used. At least 50 castings to be made

from each melt. The method of molding and the pouring temperatures are to be kept as uniform as possible and the castings are to be allowed to cool in the mold until black.

Test Bars.—Standard foundry test bars are to be poured from each melt and subjected to the usual test for the determination of the mechanical properties of the iron.

Study of Castings

The Bureau of Standards will make complete metallographic and chemical studies, including determination of gas content, of representative castings from each heat. The results of these studies will be coördinated with similar studies of castings from the same heats after enameling and with the results of the enameling tests.

Enameling Tests

Enameling tests will be made in the Ceramic Division of the Bureau of Standards and also in the following plants:

MEDIUM TEMPERATURE—DRY COAT

Wolff Manufacturing Co.
Direction of L. G. Wassman

Rundle Manufacturing Co.
Direction of M. E. Manson

WET COAT ENAMELING WITH USE OF GROUND COAT

Lindemann & Hoverson Co.
Direction of R. R. Danielson

LOW TEMPERATURE—DRY COAT

Chicago Hardware Foundry Co.
Direction of J. A. DeCelle

HIGH TEMPERATURE—DRY COAT

Pfaudler Company—Elyria Division
Direction of E. P. Poste

WET COAT CAST IRON WITHOUT USE OF GROUND COAT

Porcelain Enamel & Mfg. Company
Direction of Karl Turk

All samples are to be cleaned by sand blasting just before enameling, are not to be annealed, are to be enameled on the drag side of the casting and are to be returned to the Bureau of Standards with detailed descriptions of methods employed in enameling. In all cases, commercial enamels are to be employed but the composition of the enamels used will not be divulged.

The Chairman of the Committee will visit the Bureau of Standards in the near future to discuss the details of this program and will advise the Committee members if there is any material modification to be made.

Yours very truly,

HOMER F. STALEY, *Chairman*,

Committee on Research, Enamel Division, AMERICAN CERAMIC SOCIETY.

REPRESENTATIVE ON DIVISION OF CHEMISTRY AND CHEMICAL TECHNOLOGY NATIONAL RESEARCH COUNCIL

Dr. Wm. M. Clark, Chairman of the Research Committee of the SOCIETY has been appointed representative of the SOCIETY for a term of two years on the Chemical Division of the National Research Council.

ARTHUR FREDERICK GREAVES-WALKER

Director, Department of Ceramic Engineering North Carolina State College, Raleigh, N. C.

A department of ceramic engineering at North Carolina State College was authorized last year by the legislature and funds provided for equipment of an instructional staff. There is the assured financial support necessary to permit the department developing to the maximum facilities and service.

Mr. Greaves-Walker, after several months of negotiations, has been prevailed upon to direct this new educational department. He will also retain his interests with Stevens, Incorporated.

Mr. Greaves-Walker has an international reputation as a ceramist through his publications. He has proven his ability to manage and to solve production problems. His personality and progressiveness insures for him a place in the front rank as an educator and investigator. North Carolina State College is fortunate in having secured Mr. Greaves-Walker to direct the affairs of this new department. For a personal sketch of Mr. Greaves-Walker see *Jour. Amer. Ceram. Soc.*, **6** [1], 44(1923).

H. G. SCHURECHT LEAVES MELLON INSTITUTE

H. G. Schurecht, Senior Incumbent of the Multiple Industrial Fellowship sustained in Mellon Institute of Industrial Research by the Clay Products Association and the Eastern Clay Products Association, has resigned to accept the directorship of the research laboratory of the National Terra Cotta Society. While Mr. Schurecht assumed his new duties on September 1, it is understood that the selection of his successor has not been made by Mellon Institute.

NECROLOGY

Max F. Abbé

Announcement has been received of the death of Max F. Abbé, Chairman of the Board of Directors of the Abbé Engineering Company, on July 3, 1924. The Abbé Engineering Company has a corporation membership in this SOCIETY.

T. Wilfred Owen

T. Wilfred Owen, also a member of the SOCIETY met death recently by drowning. Mr. Owen was Ceramic Engineer for the Queen's Run Refractories Co., Inc., at their Lock Haven, Pa., plant.

BIBLIOGRAPHIES ON REFRACTORIES

The Refractories Division of the SOCIETY has ready for distribution a Bibliography of Magnesite Refractories. It has a Bibliography of Silica Refractories in the press. Several hundred references and abstracts are in manuscript form for a Bibliography on Clay Refractories. Bibliographies of other types of refractories will be compiled.

The Bibliography on Magnesite Refractories may be had by sending 10 cents postage to office of the SOCIETY's General Secretary, Lord Hall, O. S. U., Columbus, Ohio.

THE GEOLOGICAL SURVEY COMMITTEE

The Geological Survey committee is preparing for early distribution (1) a directory of dealers of ceramic materials and (2) a bibliography on clays. The Committee will welcome suggestions and information. Address Dr. S. L. Galpin, Iowa State University, Ames, Iowa.

FELDSPAR INVESTIGATION

The Bureau of Standards with some of the universities and industrial laboratories collaborating will investigate the properties and constancy of the feldspars. This is being done at the suggestion of and in coöperation with the AMERICAN CERAMIC SOCIETY.

There is "malice toward none and charity toward all" in this investigation. With eye simply on the best welfare of all, the White Wares Division of the SOCIETY has made honest effort to get to the facts regarding the availability and quality of domestic feldspar. The facts "must out." In no other wise will the ceramic manufacturers be able to produce the best ware possible and in no other wise will the feldspar producer know the use to which his products is best fitted. An illuminating lamp to the feet of both producer and consumer is the only purpose of these investigations.

The scheme and scope of investigation which is now being undertaken is set forth in the communication from Dr. George K. Burgess, Director of the Bureau of Standards. This is but one portion of the investigations to be undertaken. It is the most logical "next step." A cursory review of the milling practices has already been made and reported. This will be followed by a survey of the feldspar resources with chemical, physical, microscopic and service studies of field samples illustrative of the extent and uniformity of deposits.

Full and frank coöperation in these investigations will be given by all who are willing to do business on the basis of "the truth, the whole truth and nothing but the truth."

Enclosed you will find a brief outline of an investigation on feldspar which it is proposed to conduct at this Bureau. The investigation is to be coöperative with the AMERICAN CERAMIC SOCIETY and, as the outline indicates, is divided into two major parts.

The first is to be coöperative with other institutions and comprises tests suggested by the Whiteware Division of the CERAMIC SOCIETY. It is believed to be very desirable to determine the factor of experimental error in the determination of softening points, and chemical and screen analyses, by comparing data on the same samples from at least five separate sources. In addition, the Bureau will determine the actual fusion points (expressed in °C) and conduct an "air analysis" on all feldspars submitted.

The second part comprises tests which will be conducted solely at the Bureau and will be comparable with previous Bureau investigations of ball clay, whiting, and flint.

It has been suggested by Mr. R. V. Miller (Knowles, Taylor & Knowles Co.), as the representative of the AMERICAN CERAMIC SOCIETY, that we obtain from you a sample of each of the following feldspars: (Feldspars listed.)

The Bureau and the SOCIETY will greatly appreciate your coöperation in this matter. It is requested that you forward not less than a 100-pound sample of each of these feldspars, prepaid, to the Bureau of Standards, Washington, D. C., attention IX–I–F.

Respectfully,
(Signed) GEORGE K. BURGESS, *Director.*

FELDSPAR INVESTIGATION, BUREAU OF STANDARDS

Part I. Suggested by White Ware Division.
- A. Softening point in cones (coöperative).
- B. Fusion point (°C).
- C. Chemical analysis (coöperative).
  1. K_2O–Na_2O–CaO.MgO.
  2. SiO_2.Al_2O_3 ratio.
- D. Screen analysis (coöperative).

Part II. Suggested by Bureau.
- A. Viscosity during softening range.
- B. Effect on body.
  1. Burning range in cones and °C.
  2. Porosity.
  3. Color.
  4. Strength.
     - *a* Impact.
     - *b* Chipping.
     - *c* Quenching.
- C. Petrographic examination.

SUGGESTED COÖPERATING INSTITUTIONS

Rutgers College	New Brunswick, N. J.
New York State School of Clay-Working and Ceramics	Alfred, N. Y.
Ohio State University	Columbus, Ohio.
University of Illinois	Urbana, Ill.
General Electric Co.	Schenectady, N. Y.
Onondaga Pottery Co.	Syracuse, N. Y.
Western Electric Co.	Chicago, Ill.

INVITATION EXTENDED BY A.A.A.S.

Since the AMERICAN CERAMIC SOCIETY has become affiliated with the American Association for the Advancement of Science, all the members of the SOCIETY who are not already enrolled in the A.A.A.S. have the privilege of joining the Association without paying the usual five-dollar entrance fee. This privilege will remain open for one full year from October 1 next. We are sure that many of the members of the SOCIETY will be glad to take advantage of the privilege and will become good supporters of the broad aims of the Association. Of course the A.A.A.S. needs the support of all who are interested in the general advancement of science and education and in the coöperation of the numerous sciences toward the improvement of science, education, and knowledge in general.

We wish to call the attention of the members of the AMERICAN CERAMIC SOCIETY to the nature and work of the A.A.A.S. and to the existence of the special privilege mentioned above. After the year above defined is completed the privilege will be restricted to *new* members of the SOCIETY, who will have the privilege till one year after the next October first following their election to the SOCIETY.

NOTES AND NEWS

BUREAU OF MINES NOTES

Silica Investigations

In the course of a general study of the technology of silica, being conducted by the Department of the Interior through the Bureau of Mines, observations have been made recently in the glass-sand and ganister districts of Mapleton and Mt. Union, Pa., and Berkeley Springs, W. Va. Methods of quarrying and mining were studied, including the use of explosives. Although the workings are all open cuts in the glass-sand quarries, loading of ore is done almost entirely by hand. In only a few instances are steam shovels used.

Washing or milling plants for glass-sand are very much standardized in the two districts, with the exception of methods of handling the wet, washed sand. These varied from hand feeding of bucket elevators to overhead traveling cranes with clam-shell bucket. The output of the two districts is almost the same, as far as quality is concerned, as they are mining the same bed of sandstone and using similar methods. One pulverizing plant at Berkeley Springs was visited where the washed sand is ground in tube mills. The product is used almost entirely in the ceramic industry. In all, nine plants were visited in the two districts.

Additional samples of silica were collected and a study begun of the difference in finished product between material ground in batch type and continuous mills. In connection with this, determination of grain size of finished products was made on several samples. Screen analysis and microscopic examination were made on samples of glass sand collected.

The Milling of Garnet

Gravity separation of abrasive garnet from hornblende, minerals which are intimately associated in the New York deposits, presents difficulties owing to the small difference in the specific gravity. It is believed that a detailed study of milling methods would not only be of assistance to garnet producers, but the data obtained from such a study would be useful in its application to problems in the milling of other ores and minerals. Such a study will be undertaken by the Department of the Interior, the work being assigned to the New Brunswick, N. J. and Rolla, Mo. experiment stations of the Bureau of Mines.

Refractory Service Survey at Boiler Plants

R. A. Sherman, Department of the Interior engineer, is making observations in the vicinity of New York City, in the course of a survey of refractory service in boiler-furnace plants being made by the Bureau of Mines. Observations were recently made at Providence and Pawtucket, R. I., and near Boston, Mass. This survey gives promise of definite results in promoting the interest of power-plant engineers in refractory problems and in the obtaining of coöperation of research organizations in solving these problems.

Removal of Sulphur from Ceramic Wares

Under a general investigation into the oxidation of ceramic wares during firing, being conducted by the Interior Department at the Columbus, Ohio, experiment station of the Bureau of Mines, a study has been undertaken on a semi-commercial scale to test methods that have been developed in a laboratory way for the more rapid removal of sulphur from ceramic wares during firing.

Several shales and fire clays have been chemically and microscopically tested for suitability in the work and a procedure has been worked out for a series of semi-commercial burns. A ton of a North Columbus shale which is particularly difficult to oxidize has been obtained and a number of standard bricks made up. They will be fired in lots of fifty each. Preparations are complete for making the required measurements during the firing and of so controlling and varying the temperature and atmosphere as to get the results desired.

It is planned to fire the kiln in forty-eight hours on a compressed schedule adopted from a commercial kiln recently tested. The first few burns will be for the purpose of developing a technique.

Alum from Clay

What is believed to be a much-needed simple, cheap method for the manufacture of pure alum and aluminum salts from impure clays has been devised by Department of the Interior investigators attached to the Pacific Experiment Station of the Bureau of Mines at Berkeley, California. The process, when perfected, should replace present methods in which pure salts cost about twice as much as impure salts.

Large scale tests on the preparation of aluminum sulfate have been completed by the Bureau of Mines. In these tests, using a unit charge of one ton, the results confirm the conclusions drawn from 100-pound runs previously made, in that it is practicable by a preliminary treatment with acid to remove the iron to a mere trace and most of the potash. This leaves an iron-free residue which can be worked up into aluminum sulfate. Alunite consists of aluminum and potassium sulfates, with iron and other minerals present as impurities. Removal of the iron has been the most difficult problem. Experiments are being continued with the object of determining the best conditions of temperature, pressure, and other factors for maximum efficiency of the process.

Mineral Fillers

A study of the size and character of grains of non-metallic mineral fillers has been completed by the Department of the Interior at the Southern Experiment Station of the Bureau of Mines, Birmingham-Tuscaloosa, Alabama. Mineral fillers are those non-metallic minerals that, after being pulverized, are used in the preparation of various manufactured articles. Kaolin, whiting, chalk, ground limestone and marble, silica, ocher, mica, talc, barite, slate flour, graphite, and diatomaceous earth are the chief mineral fillers. Different forms of some of these minerals are employed; as, for example, silica may be ground quartz, or pumice, or tripoli, the fine rounded grains resulting from the weathering of chert.

Each mineral has properties that make it suitable for certain uses. These properties are color, specific gravity, the nature of the surface, and the shape and, probably of greatest importance, the size of the particles. Most fillers are used essentially as inert substances to occupy space, fill voids, or impart color, but in some lines of manufacture they have an important but not easily understood effect on the physical properties of the finished article. For example, ground barite and marble, aside from their specific gravity, have particles that are much alike in appearance and shape, and yet the

properties they impart to a rubber compound are quite different. Of chief importance in the comparison of fillers from the same mineral, and to a less degree of fillers from different minerals, are the average particle size, the variation in size from maximum to minimum, and the proportionate amounts of the different sizes; the shape of the grain ranks second and applies more especially to the comparison of fillers from different minerals.

Although fillers are used in a great number of industries, the bulk of the material goes into the following products: Paper, wall-paper, prepared roofings, rubber, paint, linoleum, oilcloth, foundry facing, plastic cements, oxychloride cement, artificial stone, polishes and scouring compounds, matches, dressing and dusting powders, various textile products, such as window shade cloth, and phonograph records.

Details of methods of determining the average particle size and proportions of grains of different sizes are given in Technical Paper 296, by W. M. Weigel, mineral technologist, copies of which may be obtained from the Department of the Interior, Bureau of Mines, Washington, D. C.

BUREAU OF STANDARDS NOTES[1]

Novel Experiment in the Casting of Heavy Clay Ware

The Bureau of Standards recently completed the drying of three experimental pots (outside dimensions 3½ feet high by 4 feet 9 inches in diameter, and a maximum wall thickness of 5 inches), designed to be used in the melting of glass. For casting each pot one and one-half tons of slip were required.

The first step in the production of these large pots was the making of the plaster mold in which they were to be cast. Ten tons of plaster of Paris were used in this undertaking, and several problems of interest developed in the course of the work. It was found that a coddle (temporary form) made of battleship linoleum and reinforced with wood slats, which had been used in previous work of this kind, was not sufficiently strong to withstand the hydraulic head of five feet of plaster slip. Special precautions were also required to adequately seal the bottom of the coddle. In addition to this the equipment available necessitated mixing and pouring as many as eight batches of three-hundred pounds of plaster (plus water) each, in the casting of a single section of the mold. Since the various sections had to be turned to the proper shape, the batches of plaster slip had to be retarded progressively so that the entire section would set uniformly. If this had not been done, the bottom part of a section would have set up too hard to be worked with the hand tools employed, while the top layer would still be too soft.

A coddle of sufficient strength was made by using Number 20 gage sheet iron secured by means of small bolts. The bottom of this coddle was sealed by setting it in a groove in the plaster base and filling this groove with plaster, which was allowed to harden before the casting was started. The groove was about one inch wide by one inch deep. After several experiments with an organic retarder it was found that the addition, to every batch of 300 pounds of plaster, of one ounce for every batch remaining to be poured produced the desired time of set. That is, if it was estimated that six batches would be required to cast a certain section, six ounces of retarder would be added

[1] Owing to the current nature of the investigations mentioned in the Technical News Bulletin, sometimes it will be impossible to supply printed information regarding them. However, in these cases, when the investigation has progressed sufficiently far, the Bureau will be pleased to furnish technical data to those engaged in the particular application of the subject, in order to avoid the delay incident to publication.

to the first, five to the next, and so on. The mold was cast and turned to shape on a surfacing wheel which is ordinarily used in grinding the faces of special refractory shapes and which, in this case, functioned as a turning wheel or lathe.

The mold was constructed according to designs developed at the Bureau and photographic records were kept of the various stages of the work.

As previously stated, one and one-half tons of slip were required to cast one pot, and no particular difficulty was experienced in this phase of the work, although it was necessary to blunge the slip in four separate batches, keeping the first agitated in an especially adapted mixer until the last was ready for casting. The body composition and deflocculating agent were the same as used in the casting of much smaller shapes, the only departure from the usual procedure being in the greater amount of time required in preparing the slip and the time required for the slip to set up in the mold.

Use of Texas Kaolin in Whiteware Bodies

The Bureau of Standards recently conducted a short investigation in a sample of kaolin taken from a large deposit in Texas. The material was practically pure white in color, very uniform and, as received, was comparatively coarse grained and without plasticity.

Six whiteware bodies, varying in ball clay content from 0 to 14 per cent, and in which the English china clay was replaced in increasing amounts by Texas kaolin, were prepared and made up in the form of test bars, circular discs, and 5-inch plates. These were fired to cones 8 and 10. The test bars were used in determining shrinkage, transverse strength, and absorption, and the discs were used in determining relative resistance to impact. In addition, several shapes were made by the casting process, using slips containing Texas kaolin. The bodies obtained were very high in transverse strength when dried. The fired bodies were of an exceptionally white color, but had a high absorption, and were correspondingly low in transverse strength and resistance to impact. The glaze specimens were very good as regards resistance to crazing. The results as a whole indicated that Texas kaolin could be used satisfactorily in whiteware bodies, but because of the relative coarseness of grains and its high refractoriness, it would require more preliminary grinding than the English clays as well as the use of a larger percentage of ball clay to produce the desired dried and burned structure in the body.

Refractory brick were also made, using the Texas kaolin, both the grog and the bond being composed entirely of this material. The brick required burning at temperatures equal to those used in the production of diaspore and silica brick, but when made in this way the product appeared to be of very good quality.

Circular on Inspection of Portland Cement

With the growing demand for the inspection of structural materials there has been an increase in the number of inquiries received at the Bureau as to proper methods for carrying out the inspection of Portland cement. Much has been written about the inspection of Portland cement, but it appears that there is a real need for a paper dealing more fully with the work from an inspection viewpoint. Based upon the experience of the Bureau in caring for Government purchases of cement, Messrs. John R. Dwyer and Roy N. Young of the cement section have prepared a paper entitled "Inspection of Portland Cement." Often an inspector who is familiar with the various mill processes involved and the routine of inspection is called upon to make a decision which has no precedent in his experience. It is not intended that this paper shall be so far reaching as to be of assistance in all such cases, but during long experience in this work at widely scattered points certain procedures of inspection as outlined have been demonstrated

as being the most effective in avoiding complications and in holding the confidence and respect of all parties to the transaction.

This paper was published as two articles appearing in the August and September 1923 issues of the *Concrete Magazine*. However, to give it wider circulation and to care for the inquiries more promptly the Bureau has prepared it as a mimeograph circular and copies may be obtained upon request. It is hoped that the information it contains will be of assistance in conducting true inspection of cement.

Service Life Tests of Screen Wire Cloth

The Bureau has been requested by the American Society for Testing Materials to take charge of exposure tests on screen wire cloth. The program will include exposure tests of standard No. 16 mesh screen, made of copper, commercial bronze, low brass, aluminum bronze, silicon bronze, and Ambrac metal. It is planned to expose the specimens at four locations; an inland location, an industrial center, on the seacoast in a temperate climate, and on a tropical seacoast. The cloth of each material will be exposed in painted frames capable of withstanding the elements. These frames will be of three types, 12 × 12 inch wood, 30 × 36 inch wood, and 30 × 36 inch metal.

The problem of suitable places for the exposure tests has been taken up with the various coöperating manufacturers, the Bureau of Mines, Bureau of Lighthouses, and the Panama Canal.

Special Refractories for Platinum

Some very satisfactory tests have been made using cast crucibles made from fused zirconia for melting platinum, chromium, and silica. One of the most interesting tests was the fusion of silica sand in a zirconia crucible in the induction furnace. No slagging or erosion of the zirconia by the fused silica could be seen on breaking apart the solidified melt. A cast crucible with walls 2 mm. thick had sufficient strength at 1750°C to hold a 150-gram melt of pure chromium. The walls of the thin crucible were without any outside support during the test.

ANNOUNCEMENT OF THE CUSHMAN GRADUATE FELLOWSHIP IN CHEMISTRY

Western Reserve University

Mr. H. D. Cushman, President of the Ferro Enameling Co. of Cleveland, has established a Graduate Fellowship in Chemistry at Western Reserve University, for the investigation of the gases dissolved in fused silicates.

The holder of the Cushman Graduate Fellowship will receive a stipend of $750.00 and exemption from tuition and laboratory fees which would amount approximately to $250.00. In addition to his research the Fellow will be permitted to pursue advanced courses toward a graduate degree. The requirements for the degree of Master of Arts could be met in one year.

This fellowship is open only to graduates of accredited colleges. Applicants should have a thorough foundation in chemistry and physics, should be experienced in the manipulation of gases, and skilled in the simpler operations of glassblowing. Letters of application must be accompanied by a recent photograph of the applicant, by a transcript of the applicant's undergraduate and graduate record, and by sealed lettres from qualified persons, indicating his character and ability.

Applications to be considered must be received not later than Septembert 6, 1942 Send applications to: The Cushman Graduate Fellowship, Morley Chemical Laboratory, Western Reserve University, Cleveland, Ohio.

ANNOUNCEMENTS OF THE COMMON BRICK MANUFACTURERS ASSOCIATION[1]

A Magazine for Brick

The brick manufacturers are at last given the opportunity to have a national magazine devoted exclusively to the interest of their product. The Directors of the Common Brick Manufacturers' Association, at their mid-summer meeting, approved the plan for the publication by the Association of a monthly magazine. The question of financial support was thoroughly discussed. While funds could be derived from advertising, it was considered that by accepting advertising they would in some measure antagonize existing publications conducted for profit, which now are friendly to us and are liberal to us in the matter of space. The other means of support is to sell subscriptions to the magazine to the brick manufacturers, and this method was decided upon. Every manufacturer may profitably send this publication to a number of architects, engineers, contractors, supply dealers and prospective builders in his own locality, and if the members indicate the coöperation, which we believe they will, the magazine will be an assured fact and will have its first issue out in September. During the coming week a prospectus showing the size and cover design of the magazine will be sent to every member of the organization, and with this a coupon for them to indicate how many subscriptions they will take. The subscription price is $1.00 a year. Every manufacturer should make up a list, from 100 to 500 names, of persons who can be developed as prospective brick buyers, and sent it to the Association. The member will be billed monthly for these subscriptions, and the work of mailing will be done at this office. There will be no expense to the member except to purchase as many subscriptions as he can use at $1.00 a year. We urge prompt response to the circular which will go out during the week.

Machinery Exhibit

In connection with the annual convention of the Common Brick Manufacturers' Association in Chicago the week of February 9, 1925, an innovation will be introduced. Large space has been rented immediately adjoining the convention hall at the Drake Hotel for a comprehensive exposition of clay working machinery and equipment. Response from the machinery manufacturers thus far has been almost unanimously favorable to this enterprise, and the brick manufacturers attending the meeting at Chicago will have an opportunity to meet a great number with whom they do business and witness a display of everything that is new and interesting in machinery and equipment. The exposition is to be made a feature of convention week and the convention sessions so arranged that there will be ample time for thorough study of the exhibits.

GREAT PROGRESS IN STANDARDIZATION SHOWN BY A.E.S.C. REPORT

There now exists the most wide-spread interest and activity in industrial standardization that has ever been shown, according to the new Year Book of the American Engineering Standards Committee.

The work of the Committee is indicative of the growth of the movement as a whole. One hundred and fifty-two projects have been completed, or are under way, and in these various projects two hundred and thirty-five national organizations, technical, industrial, governmental, are officially coöperating through accredited representatives. The

[1] Issued Aug. 9, 1924 by the Common Brick Mfrs. Assn., Cleveland, Ohio.

number of the individuals serving under various sectional committees of the different projects is nearly 1100.

Of the projects which have reached an official status, 31 have to do with civil engineering and the building trades; 25 with mechanical engineering; 15 with electrical engineering; 4 with automotive subjects; 11 with transport; one with ships and their machinery; 14 with ferrous metals; 15 with non-ferrous metals; 12 with chemical subjects; 2 with textiles; 5 with mining; 5 with the wood industry; 1 with the paper and pulp industry; and 11 projects with topics of a miscellaneous or general character.

Coöperation in joint activities between Mr. Hoover's Division of Simplified Practice and the American Engineering Standards Committee has steadily increased. In general the work of the Committee is concentrated upon standardization projects which involve technical considerations, while the Division of Simplified Practice concentrates upon such eliminations as it is possible to carry out from a consideration of statistical production data alone, or as stated in the book on trade association activities issued by the Department of Commerce, "the layman can proceed successfully with a simplification program, while it would be impossible for him to consider seriously standardization problems by himself."

In order to meet the demands made upon it by industry, and to supply the needs of the various working technical standardization committees, the American Engineering Standards Committee has greatly broadened its information services, and has added an Engineer Translator to its staff for this purpose. In this way, complete information is made available to sustaining members, trade and technical associations and other inquirers on standardization activities in foreign countries, as well as in the United States.

The information service is becoming of increasing importance in connection with foreign trade. Exporters are frequently asked to bid on goods to comply with foreign specifications, or in accordance with an unfamiliar trade name or designation, information regarding which they do not have available. Through its information service, the A.E.S.C. has on many occasions supplied copies of standards, or details of information based on a study of foreign standards, in accordance with which bids could be prepared intelligently, thus enabling the American firm to submit its bid by cable, when without such service it would have been unable to act in time.

A new development is the appointment of local representatives of the Committee in four important industrial centers. These are: K. F. Treschow, Secretary, Engineers Society of Western Pennsylvania, Pittsburgh; J. B. Babcock, Executive Secretary, Affiliated Societies of Boston, Boston; Edgar S. Nethercut, Secretary, Western Society of Engineers, Chicago; Professor George S. Wilson, Engineering Experiment Station, University of Washington, Seattle.

One of the most striking developments of the standardization movement is the increasingly important role which trade associations are playing in it. More than 140 national trade associations are officially participating in standardization projects under the auspices of the American Engineering Standards Committee. That standardization is a legitimate and constructive activity for associations is everywhere recognized, and explicitly so by a recent decree of the U. S. District Court at Columbus, Ohio.

Standardization, being essentially a coöperative undertaking, must necessarily be predicated upon some form of organization. To carry out a piece of standardization work throughout an industry, it is practically essential that there be some form of organization covering this particular industry, even though it be a loose-knit one. More and more trade associations, no matter for what purpose they may have originally been organized are going into technical work, and it is natural if not inevitable, that both trade and technical associations should eventually concern themselves to an in-

creasing extent with standardization activities. This tendency is becoming more marked on every hand.

The Year Book may be secured by addressing the American Engineering Standards Committee, 29 West 39th Street, New York City.

TEN MILLION DOLLAR CAMPAIGN[1]

The National Museum of Engineering and Industry announces its campaign for $10,000,000.

One million dollars has been assured towards the establishment of the National Museum of Engineering and Industry, Incorporated, with headquarters in the Engineering Societies Building. A campaign to raise an additional nine million dollars starts today. The president of the new organization is Dr. Elihu Thomson who today receives the Kelvin Gold Medal from the Royal Society at the Kelvin Centenary in London. The Vice Presidents are Dr. Edward G. Acheson, one of the creators of the modern abrasive industry, Dr. Leo H. Baekeland, inventor of Velox paper and Bakelite, he is President of the American Chemical Society, and Dr. Edward Weston, creator of the Weston type of electrical instruments. Its Trustees are Mr. Philip T. Dodge, Chairman of the International Paper Company, Mr. Howard Elliott, Chairman of the Northern Pacific Railroad, Dr. Ira N. Hollisk, President of the Worcester Polytechnic Institute, Dr. Elmer A. Sperry, President of the Sperry Gyroscope Company, and Mr. Worcester R. Warner, of Warner & Swasey, Cleveland, Ohio, makers of the great telescopes of the world. Mr. George E. Roberts, Vice President of the National City Bank, is Treasurer, and Mr. H. F. J. Porter, Industrial Engineer, is Secretary.

In coöperation with the Smithsonian Institution the new organization is planning to erect on its grounds in Washington a building to house the original models of early inventions and the records of constructive achievement of pioneers, inventors, and engineers in the development of transportation and industry. In this way the United States will be given the kind of institution which all the great European nations have possessed for years, and in the layout of the proposed museum use will be made of the data collected by an expert who has recently returned from a year's survey of museum practice abroad.

An important departure in the American scheme is proposed however, made necessary by the vastness of the country. In addition to the central collection at Washington special collections such as replicas of the historical exhibits will be carried to the people, also live machinery of modern processes will be placed in affiliated museums in industrial centers of every state.

Already old models and records long forgotten have been located and resurrected and this winter will be exhibited at the headquarters as a demonstration of how the ultimate collection will appear.

Incorporation was effected in March last under the laws of the District of Columbia by the "Organizing Committee of 100" composed of chairmen of boards of directors, presidents and chief engineers of industries and railroads, and professors of engineering and history in universities and colleges.

NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING

Over 260 exhibitors have been assigned space at the Third National Exposition of Power & Mechanical Engineering which will be held in the Grand Central Palace, New

[1] Natl. Museum of Eng. and Industry, 29 W. 39th St., N. Y. City, July 10, 1924.

York City, from December 1 through December 6. As this number is more than two times greater than those who had engaged space on August first a year ago, the indications are that the coming event will be of tremendous interest and importance.

The 1923 Exposition drew an attendance of 62,079 engineers, executives, financiers, operating men, as well as large numbers of engineering students with their instructors. This is an increase of 15,000 over the number who attended the 1922 Exposition.

As the expressions of appreciation and interest in the 1923 exhibit were proof of the value of the Exposition and as the large attendance of vitally interested visitors was a great satisfaction to those exhibiting, it is safe to assume that the coming event will greatly surpass all of its predecessors. The constant growth of the Exposition is interesting proof that the industries related to power and mechanical engineering are in a state of rapid development, and need the inspiration and ideas started at the Exposition. The growth of the Exposition has also been an object lesson to these industries, for in addition to giving the engineering and general public an idea of the size and importance of the industries, it has dignified the industries in the eyes of those engaged in them and presented a perspective of functions and methods that nothing else could have provided.

The Exposition will, as usual, parallel the meetings of The American Society of Mechanical Engineers and the American Society of Refrigerating Engineers. The A.S.M.E. meeting will be held in the Engineering Societies Building, 29 West 39th St., New York City, and the A.S.R.E. meeting will be held at the Hotel Astor, New York City. Plans are under way for the American Society of Heating and Ventilating Engineers to have a gathering of Local Sections during the time of the Exposition. The coöperation of the various engineering societies has been valuable, since it enables members to attend the meetings and at the same time see the interesting exhibits at the Grand Central Palace.

The management of the Exposition is assisted by an Advisory Committee of designing and operating engineers. For the coming Exposition this Advisory Committee has been augmented by George A. Horne of New York, President of A.S.R.E.; Homer Addams of New York, President of the A.S.H.V.E., and John H. Lawrence of New York. Mr. Lawrence served on the Committee the preceding year during his term as Chairman of the Power Division of the A.S.M.E.

The American Society of Mechanical Engineers, the National Electric Light Association and the National Association of Stationary Engineers are already represented on the Advisory Committee by their officers. The A.S.M.E. delegation consists of the President, Fred R. Low; Chairman of the Professional Divisions Committee, James Partington; Chairman of the Power Division, Nevin E. Funk; and the Secretary Calvin W. Rice. The N.E.L.A. is represented by the President, Walter H. Johnson, and the N.A.S.E. by Past-President, Fred Felderman. The balance of the Advisory Committee who hold over from year to year are I. E. Moultrop, Chairman, of Boston; W. L. Abbott, Chicago; N. A. Carle, Newark, N. J.; C. F. Hirshfeld, Detroit; O. P. Hood, Washington, D. C.; E. B. Katte, New York; David Moffat Myers, New York; and Fred W. Payne and Charles F. Roth, managers of the Exposition, with offices in the Grand Central Palace.

MANAGEMENT WEEK—OCT. 20-25

Management hits all branches of endeavor. Sixty-five cities are holding meetings on the same subject is somewhat unique even in this land of the unusual. Five national societies are sponsoring these activities—*i. e.*,

American Management Association
American Society of Mechanical Engineers
National Association of Cost Accountants
Society of Industrial Engineers
Taylor Society.

Should you desire specific information at any time regarding Management Week, it will be promptly given by Ernest Hartford, 25–33 West 39th St., New York, N. Y.

An official representative of each Society has been appointed to serve on a national committee on arrangements. The personnel of this Committee is as follows: Henry Bruere, the representative of the American Management Association; Sterling H. Bunnell, representing the American Society of Mechanical Engineers; W. H. Leffingwell, representing the Taylor Society; E. M. Robinson, representing the Society of Industrial Engineers, and C. R. Stevenson, representing the National Association of Cost Accountants. At the organization meeting, C. R. Stevenson was elected permanent chairman of the Committee and Ernest Hartford secretary. It is the wish of the Committee that all correspondence be directed to its secretary at the Engineering Societies' Building, 25–33 West 39th Street, New York.

To Secure Aid of Local Clubs

At present the Committee is engaged in compiling a list of the cities where there are local organizations of any of the five national societies. It is proposed to hold meetings at each of these places and to appoint as local committees the chairman or president of the local branches of the national society. Where there is no local branch, the national society will designate one of its members residing in the community to serve on the committee. These local committees, in addition to having charge of all arrangements for their local meetings, will also be encouraged to secure the interest of local civic organizations, such as the Rotary Club, Kiwanis Club, Lions Club, Chamber of Commerce, etc. The plan is to have each of these civic organizations devote its meeting during the week of October 20 to a subject on some phase of management. The keynote of the meetings this year will be Budgeting for Better Management.

The National Committee is developing a publicity bureau from which will be disseminated fortnightly the latest announcements in the development of the general plan. The Committee will also issue bulletins bi-weekly to the various sub-committees throughout the country.

The Committee will be glad to receive suggestions and constructive criticism from anybody having ideas on the subject and will also welcome the receipt of contributions from authors or suggestions of desirable speakers who may be interested in presenting papers during Management Week.

AMERICAN INSTITUTE TO HOLD BIG EXPOSITION OF INVENTIONS

Manufacturers in every American industry will be interested in the Exposition of Inventions to be held, December 8 to 13 inclusive, 1924, in the famous Engineering Societies Building, New York City. The American Institute of the City of New York is handling this display through its Inventors' Section, with behind it an experience of ninety-six years in fostering and portraying American industrial life.

A feature of the Exposition will be exhibits from the leading American industries showing developments of various machines, utilities and processing methods. In all

fields the ingenuity of the inventor and the part he has played in the progress of America will be emphasized.

In this display of American inventions the American Institute will be continuing with a new emphasis almost a century's encouragement of inventors and introduction of their works to the public. Among inventions now used throughout the world that were first displayed to the public at earlier All-American fairs of the Institute are the Morse telegraph, the Hoe lightening printing press, the McComick reaper, the Howe sewing machine, the Bell telephone, the Colt revolver, the Francis metallic life boat, and many others.

The American Institute also established the first permanent exhibit—an idea later adopted in various industries—where "machines, models, specimens and drawings" were displayed to the public. Great annual fairs of the Institute, begun in 1828 and held at such widely known places in their times as Niblo's Garden, Castle Garden, Crystal Palace, Palace Garden, the Academy of Music and Madison Square Garden, in New York City, portrayed year after year the advancements in agriculture, commerce, manufactures, science and the arts until, with the expansion of the country's business in the last quarter century, the idea developed into the more famous world fairs and national and international industrial expositions under various auspices and managements.

Arrangements for the display of working models or actual devices at the Exposition of Inventions can be arranged through a Committee of the American Institute at 47 West 34th Street, New York City. All proposed displays are subject to approval by the Institute, it being the desire to show only those things of sound worth.

ANNOUNCEMENT OF CHEMICAL EXPOSITION DATE

There will be no Exposition of Chemical Industries in 1924. The next Exposition of Chemical Industries will be held September 28 to October 3, 1925, at the Grand Central Palace, New York.

"This Exposition will not be held in the United States prior to September, 1925," states the announcement of the management. As a result of a vote of exhibitors, taken last year, the decision was definitely reached at that time not to hold the exposition in 1924, but to skip a year and hold the next one in 1925.

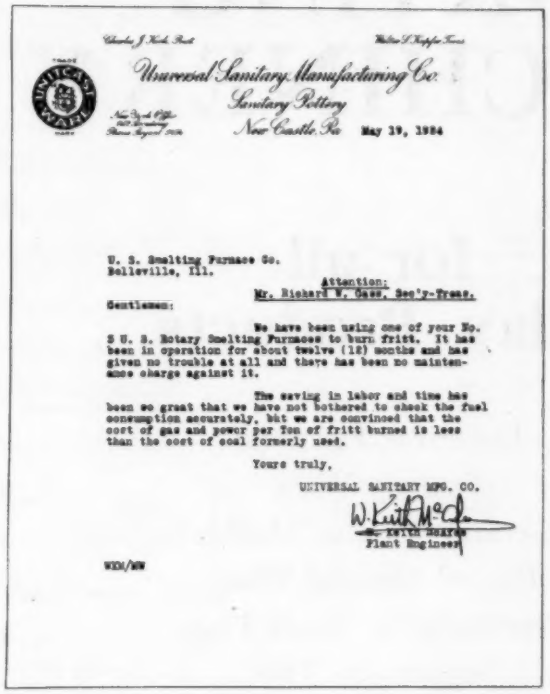
At the meeting in 1923, where time and place for the next Chemical Exposition were discussed and decided upon, the exhibitors decided by a large majority to hold all future expositions in New York, and selected the Grand Central Palace for 1925.

CALENDAR OF CONVENTIONS

Organization	Date	Place
AMERICAN CERAMIC SOCIETY (Summer Meeting)	Oct. 6–7, 1924	Los Angeles, Calif., Hotel Biltmore
AMERICAN CERAMIC SOCIETY (Annual Meeting)	Feb. 16–21, 1925	Columbus, Ohio
Am. Assn. Adv. of Science	Dec. 29, 1924—Jan. 3, 1925	Washington, D. C.
Am. Assn. of Museums	1925	St. Louis, Mo.
Am. Assn. Flint and Lime Glass Mfrs. (Quarterly Meeting)	Oct., 1924	Pittsburgh, Pa.

Am. Assn. Flint and Lime Glass Mfrs. (Annual Meeting)		Atlantic City, N. J.
Am. Chemical Meeting	Sept. 8–13, 1924	Ithaca, N. Y.
Am. Concrete Inst.	Feb. 24–27, 1925	Chicago, Ill.
Am. Electrochemical Society	Oct. 2–4, 1924	Detroit, Mich.
Am. Engineering Council (Administrative Board)	Oct. 17–18, 1924	Chicago, Ill.
Am. Face Brick Assn.	Dec. 2–4, 1924	Hot Springs, Va.
Am. Foundrymen's Assn.	Oct. 11–16, 1924	Milwaukee, Wis.
Am. Gas Assn.	Oct. 13–17, 1924	Atlantic City, N. J.
Am. Inst. of Architects	1926	Atlanta, Ga.
Am. Inst. Min. & Met. Engineers	Oct. 13–15, 1924	Birmingham, Ala.
Am. Mining Congress	Sept. 29–Oct. 4, 1924	Sacramento, Calif.
Am. Soc. of Mechanical Engineers	Dec. 1–4, 1924	New York City
Am. Soc. for Steel Treating	Sept. 22–26, 1924	Boston, Mass.
Am. Zinc Institute, Inc.	1925	St. Louis, Mo.
Assn. Iron and Steel Electrical Engrs.	Sept. 15–19, 1924	Pittsburgh, Pa.
Common Brick Mfrs. Assn. of Am.	Feb. 9–13, 1925	Chicago, Ill.
Eastern Paving Brick Mfrs. Assn.	Dec., 1924	New York (?)
Exposition of Inventions	Dec. 8–13, 1924	New York City
Franklin Inst. Centennial	Sept. 17–19, 1924	Philadelphia, Pa.
Grinding Wheel Mfrs. Assn. of U. S. and Canada	Sept. 12	Pike, N. H.
The Gypsum Industries	Sept. 23–24, 1924	Chicago, Ill.
Hollow Bldg. Tile Assn.	Jan., 1925	Chicago, Ill.
Management Week (Auspices of Am. Soc. of Mech. Engrs.)	Oct. 20–25, 1924	New York City
Natl. Academy of Sciences (Joint Meeting) Harvard Univ. and Am. Acad. of Arts and Sci.	Nov. 11–12, 1924	Boston, Mass.
Natl. Assn. Brass Mfrs.	Sept. 17–18, 1924	Cleveland, Ohio
Natl. Assn. of Mfrs.	May, 1925	N. Y. City
Natl. Assn. of Mfrs. of Pressed and Blown Glassware	March, 1925	Pittsburgh, Pa.
Natl. Assn. of Stove Mfrs.	May 13–14, 1925	New York City
Natl. Clay Products Industries Assn.	April, 1925	Chicago, Ill.
Natl. Glass Distributors Assn.	Dec., 1924	Pittsburgh, Pa.
Natl. Paving Brick Assn.	Dec., 1924 or Jan., 1925	
Natl. Safety Council	Sept. 29–Oct. 3, 1924	Louisville, Ky.
N. J. Clayworkers Assn. and E. Sect. of the Amer. Ceram. Soc.	Dec., 1924	New Brunswick, N. J.
Refractories Mfrs. Assn.	Oct. 3, 1924	Pittsburgh, Pa.
Tile & Mantel Contractors' Assn. of America	Feb. 9, 1925	Louisville, Ky.
U. S. Potters Assn.	Dec., 1924	Washington, D. C. (?)
Western Paving Brick Assn.	Jan., 1925	Kansas City, Mo.

U. S. ROTARY SMELTING FURNACE
installed in
POTTERY PLANT SHOWS LARGE SAVING



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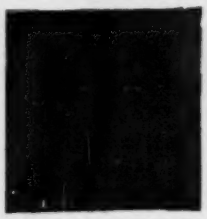

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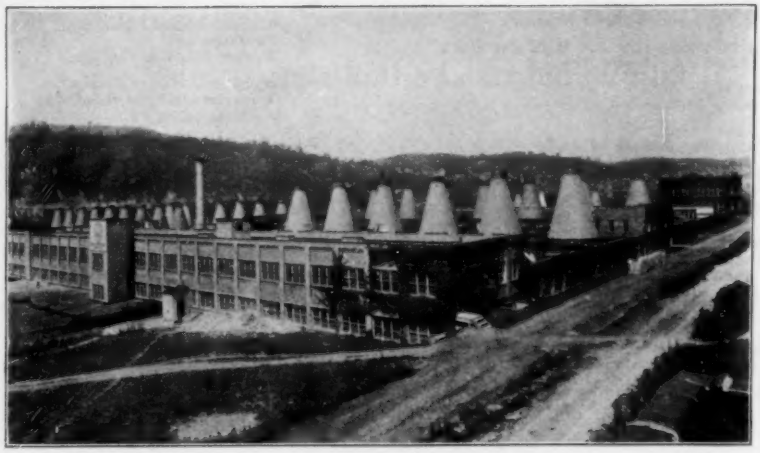

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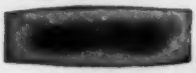
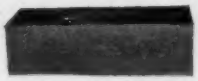


Swollen brick with black center



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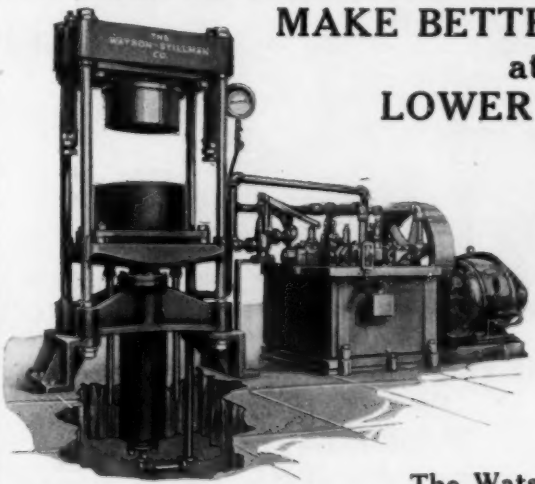

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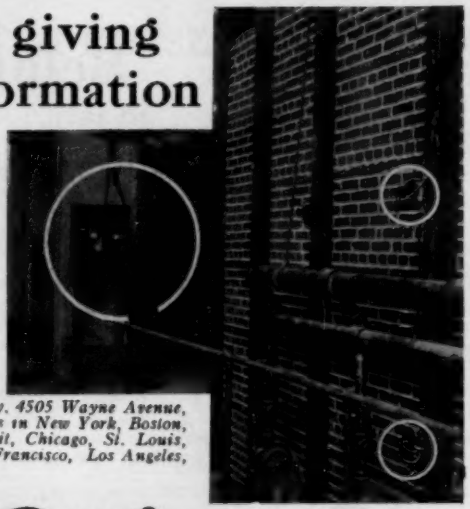

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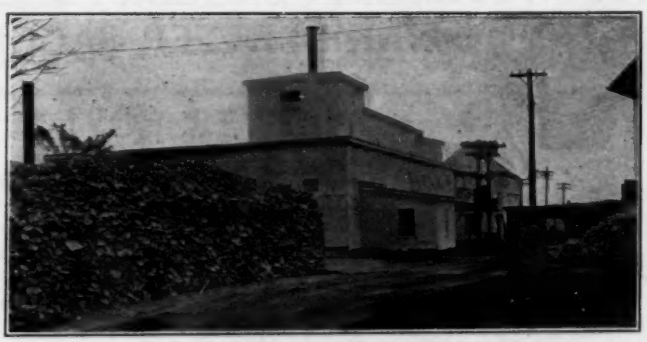
Most used in the world

Four thermocouples are installed in this Muffle Type Biscuit-Kiln—two at top and bottom of left side; two at top and bottom of right side of back.



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Mr. H. M. Richards has just recently been appointed district manager in charge of the Cleveland District Office of The American Rolling Mill Company. For a number of years he was located at the home offices of the company, and in recent years has been attached to the Pittsburgh District Office. Mr. J. T. Hagan, of Cleveland, is associated with Mr. Richards in his new work, and the office is now established at 1408 B. F. Keith Building.

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American Ceramic Society

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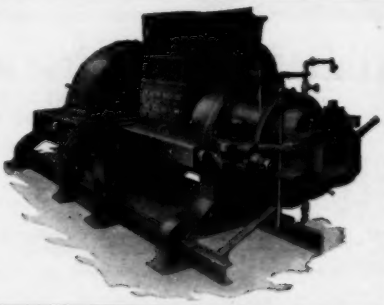

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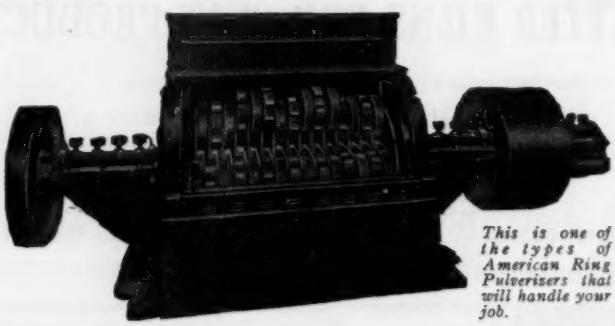

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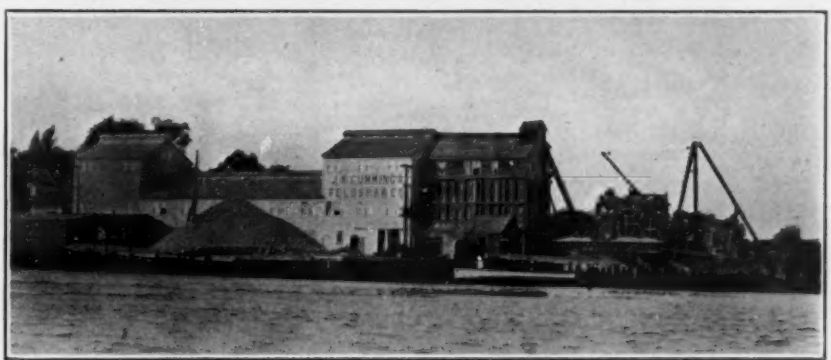

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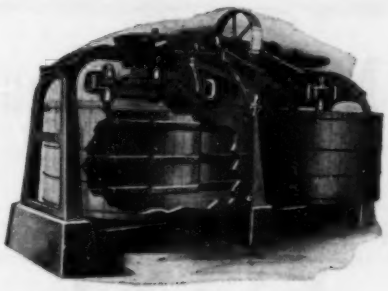

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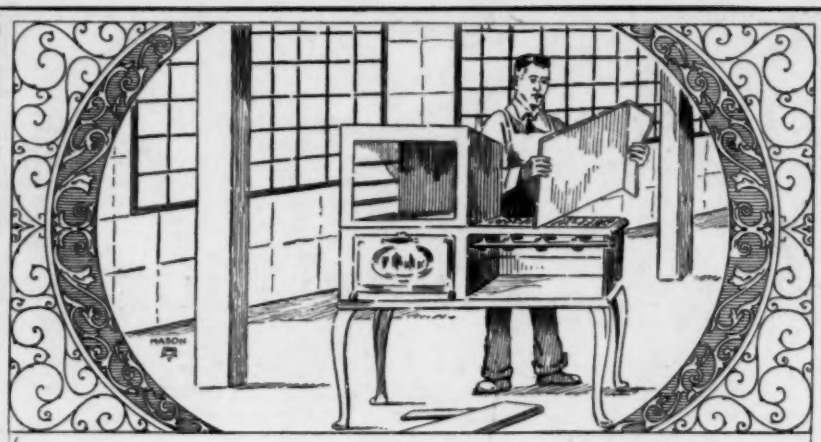

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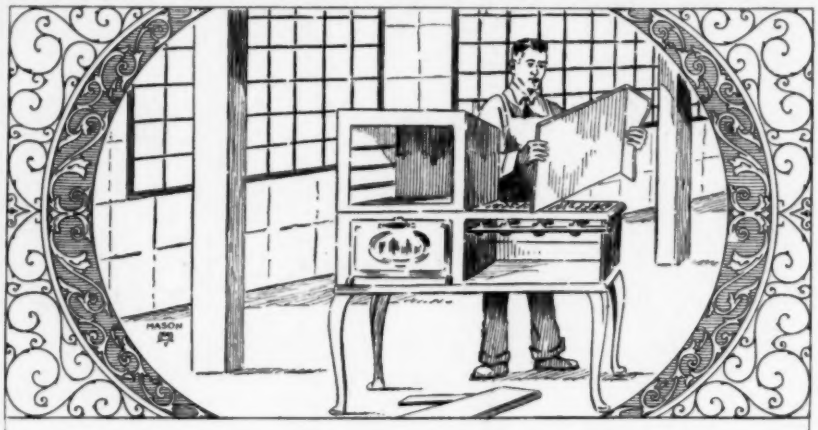

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